AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT	1. CONTRACT ID CODE	PAGE OF PAGES 1 1

2. MODIFICATION NO.:	3. EFFECTIVE DATE	4. REQUISITION/PURCHASE REQ. NO.	PROJECT NO. *(If applicable)*
0003	JUN 04, 2004	W81W3G-2035-7181	

6. ISSUED BY CODE CA31	7. ADMINISTERED BY: CODE E1P0100
Department of the Army Baltimore District, Corps of Engineers Contracting Division P.O. Box 1715 Baltimore MD 21203-1715	Contracting Division, Contracts Branch CENAB-CT-C 10 S. Howard ST. Room 7000 Baltimore, MD 21203-1715

8. NAME AND ADDRESS OF CONTRACTOR *(No., street, county, State and ZIP Code)*	(x)	
	X	9A. AMENDMENT OF SOLICITATION NO. W912DR-04-S-0001
		9B. DATED *(SEE ITEM 11)* MAY 19, 2004
		10A. MODIFICATION OF CONTRACT/ ORDER NO.
		10B. DATED *(SEE ITEM 13)*
CODE	FACILITY CODE	

11. THIS ITEM ONLY APPLIES TO AMENDMENTS OF SOLICITATIONS

☐ The above numbered solicitation is amended as set forth in Item 14. The hour and date specified for receipt of Offers **is not extended**.

DATE OF RECEIPT OF PROPOSALS 4:00 PM, LOCAL TIME JUN 17, 2004

Offers must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation or as amended, by one of the following methods:
(a) By completing Items 8 and 15, and returning 1 copies of the amendment; (b) By acknowledging receipt of this amendment on each copy of the offer submitted; or (c) By separate letter or telegram which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter, provided each telegram or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.

12. ACCOUNTING AND APPROPRIATION DATA *(If required)*

13. THIS ITEM APPLIES ONLY TO MODIFICATIONS OF CONTRACTS/ORDERS,
IT MODIFIES THE CONTRACT/ORDER NO. AS DESCRIBED IN ITEM 14.

	A. THIS CHANGE ORDER IS ISSUED PURSUANT TO: *(Specify authority)* THE CHANGES SET FORTH IN ITEM 14 ARE MADE IN THE CONTRACT ORDER No. ITEM 10A
	B. THE ABOVE NUMBERED CONTRACT/ORDER IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES *(such as changes in paying office, appropriation date, etc.)* SET FORTH IN ITEM 14, PURSUANT TO THE AUTHORITY OF FAR43.103(b)
	C. THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF: changes clause FAR 52.243.1
	D. OTHER *(Specify type of modification and authority)*

E. IMPORTANT: Contractor __ is not, __ is required to sign this document and return ____ copies to the issuing office.

14. DESCRIPTION OF AMENDMENT/MODIFICATION *(Organized by UCF section headings, including solicitation/contract subject matter where feasible.)*

RELOCATE ENVIRONMENTAL TESTING MISSION
ABERDEEN PROVING GROUND, MARYLAND

SPECIFICATIONS:

1) Page 01050-2, Paragraph 1.2.2: Add the following to this paragraph: "A geotechnical report is attached to the end of this section."

2) Section 01050: Immediately after this section, add the attached "Final Geotechnical Report."

Except as provided herein, all terms and conditions of the document referenced in Item 9A or 10A, as heretofore changed, remains unchanged and in full force and effect

15A. NAME AND TITLE OF SIGNER *(Type or print)*		16A. NAME AND TITLE OF CONTRACTING OFFICER (Type or print)	
15B. CONTRACTOR/OFFEROR ______________ *(signature of person authorized to sign)*	15C. DATE SIGNED	16B. UNITED STATES OF AMERICA BY ______________ *(Signature of Contracting Officer)*	16C. DATE SIGNED

US Army Corps of Engineers
Baltimore District

May 2004

RELOCATE ENVIRONMENTAL TESTING MISSION

ABERDEEN PROVING GROUND, MARYLAND

FINAL GEOTECHNICAL REPORT

Prepared by:
U.S. Army Engineer District, Baltimore
Engineering Division
Geotechnical Branch
May 2004

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APPENDICIES

Appendix A - Vicinity Map, Location Plan

Appendix B - Boring Location Plan, Boring Logs

Appendix C - Soil Test Results

Appendix D - Pavement Design Calculations, Pavement Details

Appendix E - Foundation calculations, Slab Loading Charts

Final Geotechnical Report
Relocate Environmental Testing Mission
Aberdeen Proving Ground, Maryland
May 2004

1. PROJECT DESCRIPTION AND LOCATION: The proposed project consists of constructing a new 10,000 square foot single-story pre-engineered metal structure. Interior walls will be constructed of reinforced concrete masonry units (CMU). A gravel surfaced access road, 10 vehicle POV parking area, and temperature conditioning (control) pad will also be constructed. The location of the proposed facility is located at Aberdeen Proving Grounds behind the security fence. The site is accessed from Surveillance Range Road. Appendix A contains a Vicinity Map and Location Plan. The proposed site is relatively flat, falling from north to south and is currently heavily wooded.

2. GEOTECHNICAL SCOPE OF WORK: The project scope of work consists of the geotechnical aspects pertaining to the design of the foundations, exterior gravel roadways and pads, and earthwork requirements for the proposed facility.

3. SITE INVESTIGATION:

   A. Subsurface Exploration. Subsurface Exploration was performed in April 2004 and consisted of 9 drill holes. Three drill holes were completed within the limits of the building to a depth of 31.5 feet and six drill holes were completed within the limits of the gravel roadway and conditioning pad to a depth of 6 feet. All drill holes were accomplished by the Standard Penetration Test Procedure (SPT) per ASTM D 1586 using a 1-3/8-inch ID x 2-foot 8-inch long split spoon sampler. Sample spoons were advanced by a 140-pound hammer free falling 30 inches. SPT's were completed at 2.5-foot intervals and the blow counts recorded for each 0.5-foot drive. The SPT provided the necessary soil samples to evaluate the distribution of soil types, groundwater elevations, in-situ moisture contents throughout the project area, and blow count data which indicates the relative density and consistency of the soils. Drill hole locations and corresponding boring logs are located in Appendix B.

   B. Laboratory Testing. All SPT soil samples were visually inspected and assigned a Unified Soil Classification System (USCS, ASTM D 2487) classification by an experienced laboratory technician. Index properties of samples representative of soil stratification were determined by performing mechanical sieve analysis, Atterberg limits, and in-situ water contents. The results of these tests are presented in Appendix C and are reflected in the final boring logs shown in Appendix B.

4. SITE CONDITIONS:

   A. Regional Geology. The project site lies within a geologic area known as the Atlantic Coastal Plain Physiographic Province approximately 4.5 miles southeast of the "fall line". The "fall line" represents the boundary separating the Coastal Plain from the Piedmont Physiographic Province. The Coastal Plain is a wedge of sedimentary deposits which gradually thickens to the southeast and overlies the crystalline bedrock of the Piedmont. The site soils consist of transported terrace deposits of the Talbot Formation of the Quaternary Period. Groundwater and soil stratigraphy are discussed in detail in paragraph Subsurface Conditions.

B. Subsurface Conditions.

a. Soil Stratigraphy:

The surficial soils at the site of the proposed Relocate Environmental Testing Mission project are coastal deposits consisting lean clays and silts (CL and ML), of silty sands (SM) and coarser sands (SP and SW). The penetration resistance (N-value) of the SPT's indicates the soils to have relative densities ranging from loose to medium dense.

b. Groundwater: Groundwater levels were recorded during drilling, when first encountered, on completion of the hole, and 24-hours after completion of the hole. Groundwater levels were encountered at depths ranging between 5 to 10 feet below grade, and rose to as high as 1 foot below grade within 24 hours after the hole was completed. Consequently, the installation of utilities and foundations may be impacted by groundwater conditions.

5. SATISFACTORY BACKFILL MATERIALS AND COMPACTION REQUIREMENTS: Satisfactory fill and backfill materials beneath roadways, pads, and within the building footprint shall be classified in accordance with ASTM D 2487 as SM, SC, SW-SC, SW-SM, GM, GC, GW-GC, GW-GM, CL or ML. Satisfactory fill and backfill materials, as defined above, shall be placed in loose lifts not exceeding 8-inches. Lift thickness shall be limited to 6-inches where hand operated compaction equipment is used. To achieve the desired long-term soil strength characteristics, all fill, backfill and subgrade materials within the building footprint and beneath pavements shall be compacted at moisture contents within plus or minus 2 percent of optimum moisture to 90 percent and 95 percent of laboratory maximum density - in accordance with ASTM D 1557 - for cohesive and cohesionless soils respectively. In grassed overlot areas, higher moisture contents are allowed as long as 85 percent and 90 percent compaction – in accordance with ASTM D 1557 - for cohesive and cohesionless soils respectively is achieved. Heavy equipment for spreading and compacting backfill shall not be operated closer to foundation or retaining walls than a distance equal to the height of backfill above the top of the footing.

6. DRAINAGE AND WATER CONTROL: Proper drainage and protection measures shall be employed during the progress of the work to prevent soils from being rendered unsuitable for subgrade, fill or backfill. These measures include such things as proper grading, sealing soils with a roller prior to rain events, proper scheduling of earthwork activities (i.e. in summer), etc. Provisions will be incorporated into the contract specifications to ensure that the contractor employs such protective measures.

7. TEMPORARY EXCAVATIONS: Temporary excavations more than 4 feet high shall be shored or cutback to a 2H on 1V slope. Temporary excavations adjacent to structures may be

cut back on a 2H to 1V slope with the top of the excavation beginning 10 feet away from the outside edge of the footing of the existing structure. Where cutting back the excavation is not practical, the excavation shall be shored.

8. PAVEMENTS:

A. References: Proposed pavements were designed to meet both strength and frost protection requirements in accordance with the latest Department of the Army criteria. The following references were used in the design of the pavements:

TM 5-822-2	Jul 87	General Provisions and Geometric Design for Roads, Streets, Walks, and Open Storage Areas
TM 5-822-5	Jun 92	Pavement Design for Roads, Streets, Walks, and Open Storage Areas
TM 5-809-12	Aug 87	Concrete Floor Slabs On Grade Subjected to Heavy Loads
TM 5-822-12	Sep 90	Design of Aggregate Surfaced Roads and Airfields

PCASE Pavement design programs located at http://www.pcase.com.

B. Pavement Sections: This gravel surfaced pavement section illustrated below shall be utilized for the access road, parking area, and Temperature Control Pad. Substantiating design calculations and details for the gravel surfaced roadway and interior concrete slab are included in Appendix D.

GRAVEL SURFACED PAVEMENT SECTION

8” Dense Graded Aggregate (DGA) Base Course
(placed in two lifts)
Stabilization Geotextile

INTERIOR CONCRETE PAVEMENT SECTION (Areas Subjected to Forklift Traffic)

6” Concrete (5000 psi compressive strength @ 28 days)
with 6 X 6 W2.9 W2.9 placed 2.5 inches below concrete surface
4” Dense Graded Aggregate
10-mil polyethylene sheeting (vapor barrier)
4” Capillary Water Barrier
Stabilization Geotextile

Where subgrade stabilization is required as defined in paragraph Subgrade Stabilization, the stabilization geotextile shall be placed beneath the subgrade stabilization layer, otherwise the stabilization geotextile shall be placed directly beneath the capillary water barrier or DGA base course for interior and exterior pavements respectively.

C. Traffic:

Traffic for the exterior gravel roadway was unknown and therefore was designed for a Design Index of 2 to accommodate up to 70 vehicles per day with no more than 7 three, four or five-axle trucks per day. The interior 6-inch concrete pavement section was designed to accommodate a forklift with 6 kip maximum load capacity for up to 250 operations per day for 25-years and a forklift with 15 kip maximum load capacity for up to 10 operations per day for 25-years. If these traffic loadings are underestimated, this office shall be contacted such that the pavement sections can be redesigned.

D. Subgrade: A California Bearing Ratio (CBR) of 3.5 was used for the design of the gravel roadways and a modulus of subgrade reaction (k-value) of 100 pci was used for the design of the interior concrete pavements (however, the k-value of 100 pci was increased to an effective k-value of 150 pci to take into account the base course beneath the interior floor slab). The CBR and k-value are based upon empirical correlations from the anticipated *stable* in-situ soil conditions. To ensure a stable subgrade beneath exterior pavements and interior floor slabs, the subgrades shall be proofrolled with a minimum 10-ton dump truck to identify soft unstable subgrade soils. Soft unstable subgrade soils shall be removed and stabilized as indicated in paragraph Subgrade Stabilization.

E. Concrete: A 28-day concrete compressive strength of 5000 psi is required for interior concrete pavements subjected to vehicular traffic.

F. Joints in Interior Concrete Pavements and Slabs: The spacing of control (construction or contraction) joints for the interior concrete slabs subjected to forklift traffic shall not exceed 15 feet where no steel reinforcement is used and 25 feet when 6 X 6 W2.9 W2.9 welded wire mesh placed 2.5" below the surface is used; the length dimension shall not exceed the width dimension of the slab by more than 25 percent. To ensure good load transfer between the joints, ¾-inch diameter dowels, 16 inches long spaced 12 inches on-center (o.c.) with one end painted and oiled are required in all control joints. Dowels shall be placed at a depth of (3 inches ± 3/8 inches) below the concrete surface. Reinforcing steel shall not be carried through the joints.

G. Subsurface Drainage (Subdrains): The in-situ subgrade materials at the proposed site are moisture sensitive and frost susceptible. However, due to the difficulty in providing positive drainage away from the base course of the pavement section as a result of the flatness of the site and high groundwater table, and since the exterior pavement sections will be gravel surfaced therefore requiring annual maintenance, a pavement subdrainage system will not be implemented into the pavement section.

H. Base Material and Vapor Barrier/Retarder Beneath Interior Slabs: Interior concrete slabs placed directly upon a vapor barrier are more likely to curl due to the moisture gradient between the top and bottom of the slab than slabs placed upon granular base. Therefore, to reduce the potential for curling, the interior concrete slabs shall be constructed upon 4 inches of DGA underlain by 4 inches of capillary water barrier. A 10-mil vapor barrier shall be placed between the DGA and capillary water barrier thus providing a granular barrier between the concrete slab and vapor barrier. Prior to placing the vapor barrier upon the capillary water barrier, approximately 0.5 inches of concrete sand meeting ASTM C33 shall be rolled into the surface of the capillary water barrier to reduce the possibility of puncture to the vapor barrier. The vapor barrier shall be a polyethylene sheeting with a minimum thickness of 10 mil. The capillary water barrier shall consist of clean, crushed, nonporous rock, crushed gravel or uncrushed gravel. The maximum particle size shall be 1-1/2 inches and no more than 2 percent by weight shall pass the no. 4 size sieve. The capillary water barrier shall be compacted with a minimum of two passes of a hand operated plate-type vibratory compactor.

I. Dense Graded Aggregate (DGA) Base Course: Dense Graded Aggregate shall be continuously graded within the limits of one of the following gradations illustrated in Table 8.1. Gradation No. 3 corresponds to the gradation of Graded Aggregate Base of the Maryland DOT Standard Specifications For Construction and Materials, 2001, Table 901A "AGGREGATES". Dense Graded Aggregate base material shall be placed at 95 percent maximum dry density at optimum moisture in accordance with AASHTO T 180.

Table 8.1: Dense Graded Aggregate (DGA) Base Course

Sieve Designation	Percentage by Weight Passing Designated Square-Mesh Sieve		
	No. 1	No. 2	No. 3
2-inch	100	---	100
1-1/2-inch	70-100	100	95-100
1-inch	45-80	60-100	---
3/4-inch	---	---	70-92
1/2-inch	30-60	30-65	---
3/8-inch	---	---	50-70
No. 4	20-50	20-50	35-55
No. 10	15-40	15-40	---
No. 30	---	---	12-25
No. 40	5-25	5-25	---
No.200	0-10	0-10	0-8

J. Subgrade Stabilization:

The subgrade beneath the building footprint and exterior gravel surfaced roadway areas (including access roadway, parking area, and temperature control pad) shall be proofrolled in the presence of the Contracting Officer to identify isolated areas of soft, wet and unstable subgrade soils. Proofrolling shall consist of the application of at least five coverages with a loaded (approximately 10 CY dump truck) dump truck weighing a minimum of 10 tons. Proofrolling shall be completed during dry weather when the subgrade is not saturated from precipitation to avoid degrading an otherwise acceptable subgrade. Areas in which substantial pumping of the subgrade is observed and the in-situ moisture contents are 5 percent or greater above optimum moisture content shall be stabilized as indicated below. Subgrade stabilization is not required in areas where pumping is not observed when subjected to a 10-ton proof roller or soils are less than 5 percent above optimum moisture. These areas where subgrade stabilization is not required shall be dried back to within approximately plus 2 percent of optimum, plowed, disked, or otherwise broken up, thoroughly mixed, and compacted to at least 90 percent laboratory maximum density for cohesive materials or 95 percent laboratory maximum density for cohesionless materials as defined in paragraph SATISFACTORY BACKFILL MATERIALS AND COMPACTION REQUIREMENTS. Measurement and Payment for subgrade stabilization shall be measured and paid for as a unit price item.

Where proofrolling operations indicate the need for subgrade stabilization of unstable in-situ subgrade materials beneath the proposed gravel surfaced pavements (and slabs) and buildings, the area to be stabilized shall extend laterally 5.0-feet beyond the edge of the unstable area. Stabilization shall consist of 12.0-inches of Dense Graded Aggregate base materials placed upon a stabilization geotextile placed directly upon the undisturbed subgrade. To bridge the wet subgrade soils, the 12.0-inch lift of Dense Graded Aggregate base material shall be placed between 90 and 95 percent maximum dry density at optimum moisture in accordance with AASHTO T 180. Vibratory compaction shall be used cautiously to minimize the "wicking up" of moisture from the wet subgrade soils into the stabilization layer therefore jeopardizing the stability of the stabilization (bridging) layer. The stabilization geotextile shall be a woven or non-woven geotextile except that heatbonded non-woven and slit film woven geotextile shall NOT be used. The geotextile shall meet the requirements of Class 1 Survivability in accordance with AASHTO M 288-96. The geotextile shall have MARV hydraulic properties meeting the requirements of AASHTO M 288-96 geotextile criteria for stabilization (i.e. minimum permittivity of 0.05 sec^{-1} and an apparent opening size (AOS) equal or less than No. 40 sieve).

9. FOUNDATIONS:

A. Structural Design Parameters: The Structural Engineer (STV Incorporated) has estimated the maximum column and wall footing loadings for the pre-engineered structure as follows:

maximum interior wall load: 2.4 kips per linear foot

maximum downward column load: 25 kips

B. Foundation Requirements: All footings shall bear a minimum of 29 inches below finished grade or 12 inches into undisturbed subgrade, whichever is deeper to satisfy strength and frost requirements. In addition, due to the extensive amount of grubbing anticipated for the removal of tree stumps, footings shall be lowered as necessary to bear beneath the grubbing depth.

Footings shall be sized for net allowable bearing capacity of 2000 psf . Total settlements are anticipated to be less than 1-inch and differential settlements are expected to be less than ½ -inch. According to the structural engineer, downward maximum column loadings of 25 kips will be distributed along an exterior continuous 2 foot wide grade beam with a lateral loading of 23 kips resisted by the slab, and an uplift loading of 42 kips resisted by the dead weight of the structure. Per the contract drawings, an interior wall loading of 2.4 kips per lf will be distributed along a 3-foot wide wall footing bearing at elevation 17.5 feet (approximately 3.5 feet below finished floor elevation). The minimum strip footing width shall be 2.0 feet to prevent a "punching" or local shear failure. Substantiating settlement and bearing calculations are shown in Appendix E.

Prior to placement of foundations, the Contractor's independent soil testing agency shall inspect footing elevations and conduct Cone Penetrometer tests (Dynamic Cone Penetrometer (DCP) for cohesionless materials (sands) and Static Cone Penetrometer for cohesive materials (clays)) to verify a minimum allowable bearing capacity of 2000 psf. Cone penetrometer tests shall be conducted every 25-feet along the continuous wall footings and grade beams (with one directly beneath each column location along the grade beam). The cone penetrometer test shall be conducted at the foundation bearing elevation and continue to a depth of 2-feet below the bearing elevation. The cone penetrometer test shall be completed in accordance with the manufacturer's recommendations.

C. <u>Loadings Subjected to Interior 6-inch Floor Slab</u>: The 6-inch interior slabs underlain by 8-inches of Base Course can support a maximum stationary live load of 1200 psf. The maximum allowable wall load located within the center of the slab or along the free edge of a slab can be determined utilizing the charts in Appendix E. Details for thickened slab widths and free edge conditions beneath wall loadings are illustrated in figure 3-1 in Appendix E. An *effective* modulus of subgrade reaction value (k) of 150 pci shall be used for the 8-inches of base course beneath the slab when utilizing the charts in Appendix E.

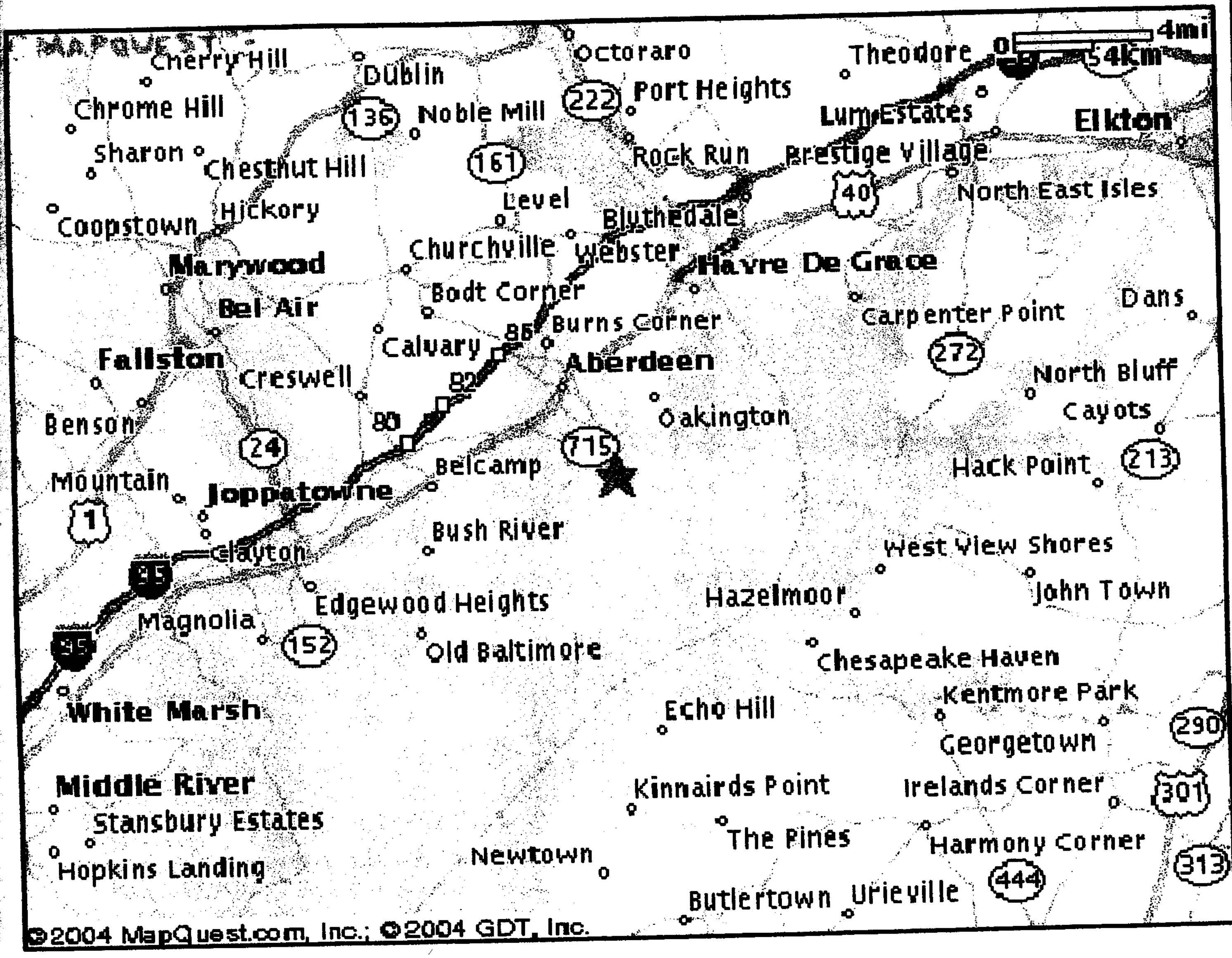
D. <u>Seismic Site Classification in Accordance with FEMA 302-1998</u>: In accordance with chapter 4 of the 1997 edition of the NEHRP RECOMMENDED PROVISIONS FOR SEISMIC REGULATIONS FOR NEW BUILDINGS AND OTHER STRUCTURES, the properties of the in-situ site soils classify the site as a Site Class E. This is based upon the N-method and Su method as defined in paragraphs 4.1.2.1, 4.1.2.2 and 4.2.3 of the latter NEHRP reference.

10. <u>ENVIRONMENTAL CONSIDERATIONS</u>: The site has been assigned a CAT III designation for environmental contamination due to the potential for encountering buried un-exploded ordinance (UXO). The proposed site was an impact area and therefore must be swept and cleared of UXO.

11. <u>POINT OF CONTACT</u>: Any questions or comments regarding this report shall be directed to Mr. David Tucker, P.E. at 410-962-6823.

APPENDIX A

Vicinity Map
Location Plan



VICINITY MAP

N.T.S.

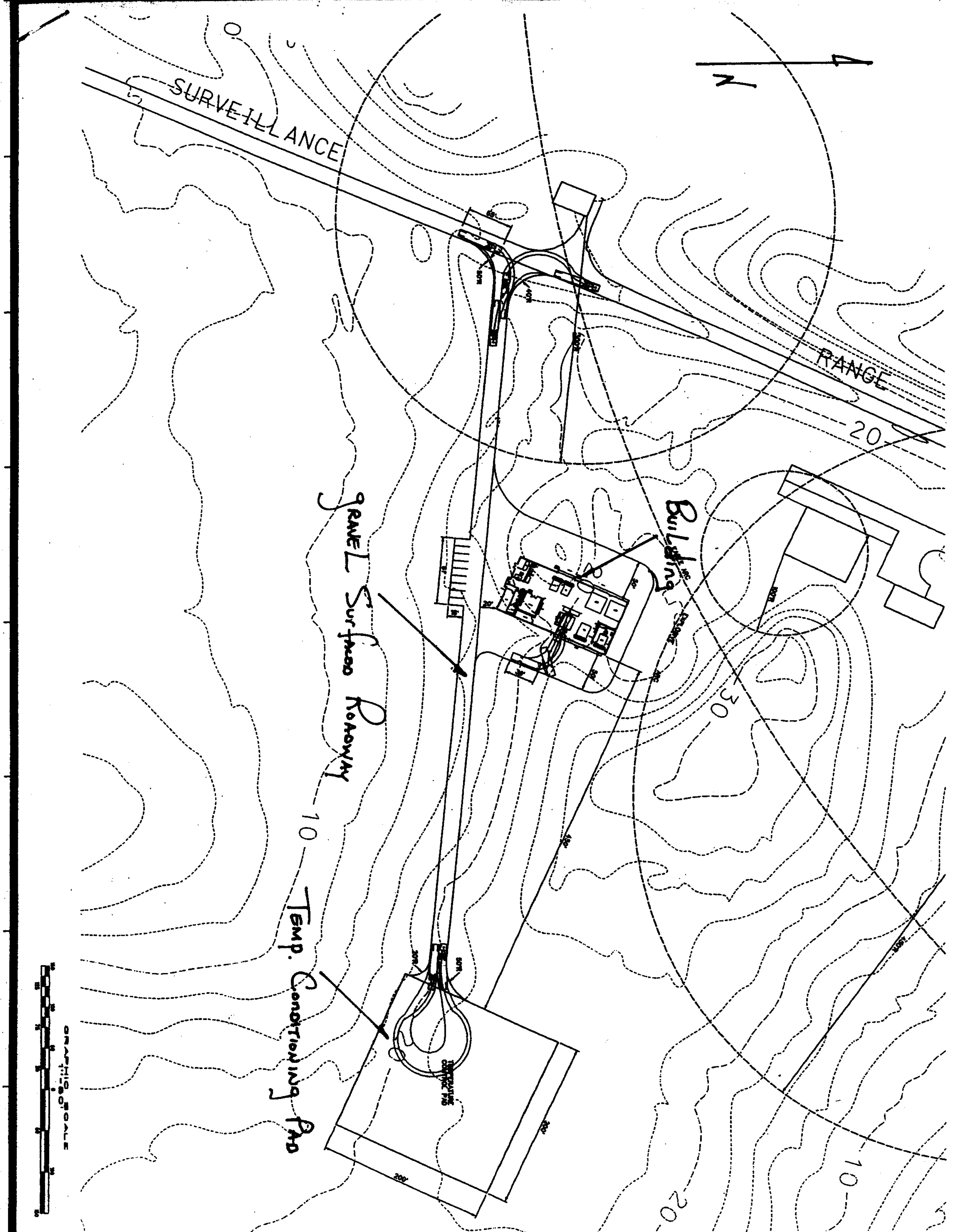


Plate:

Sheet Number:

LOCATION PLAN

U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND

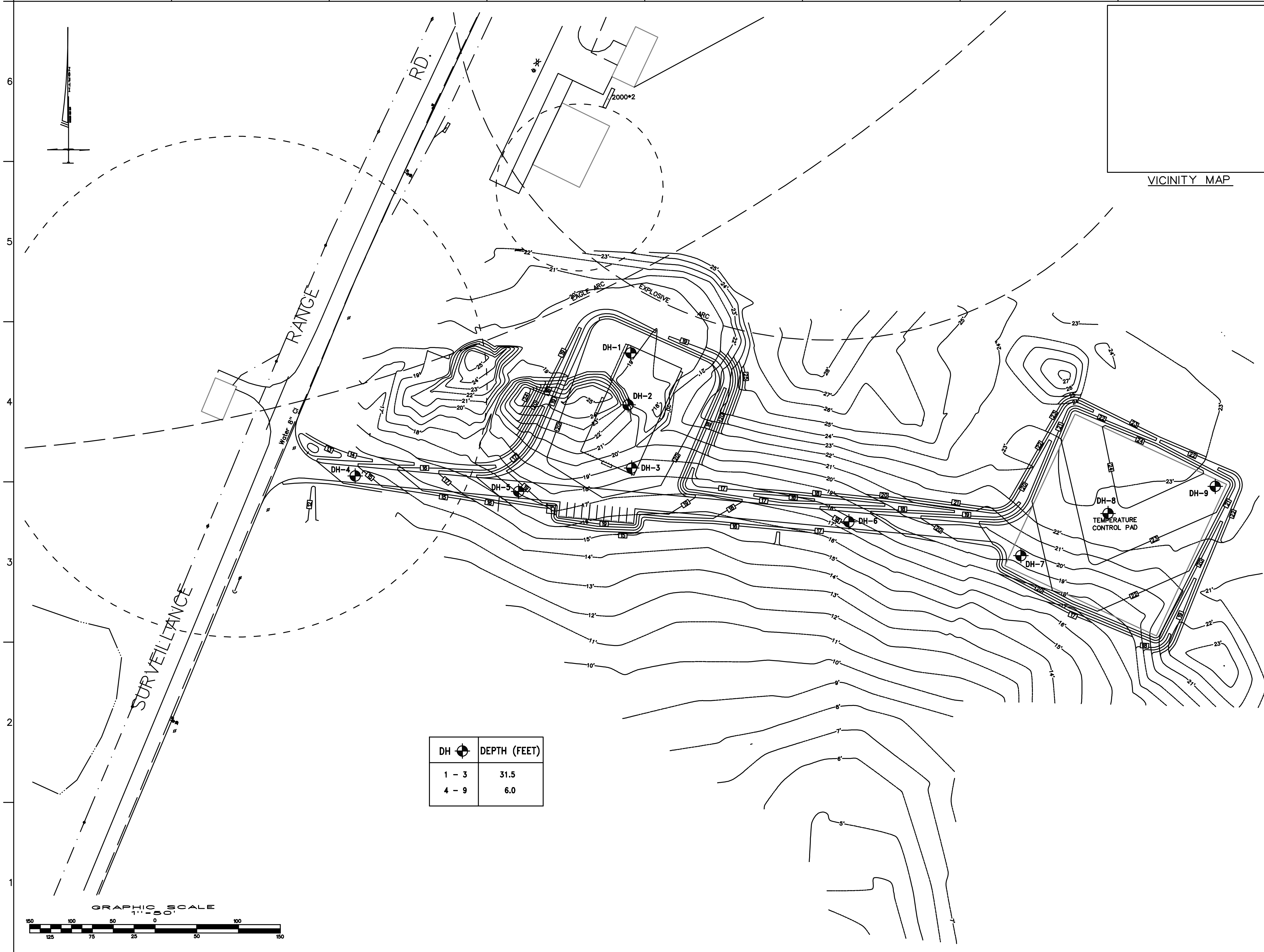
Designed by:	Date:	Rev.
Dwn by: Ckd by:	Design file no.	
Reviewed by:	Drawing Number:	
Submitted by:	File name: Plot date: Plot scale:	
Chief, Branch		

Mark	Description	Date	Appr.	Mark	Description	Date	Appr.

US Army Corps of Engineers
Baltimore District

APPENDIX B

Boring Location Plan
Boring Logs



DH	DEPTH (FEET)
1 – 3	31.5
4 – 9	6.0

US Army Corps of Engineers
Baltimore District

U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND

AMOS BAILEY ARNOLD + ASSOC., INC.
3600 Clipper Mill Road Suite 300
Baltimore, MD 21211

Designed by:
Dwn by:
Ckd by:
Reviewed by: Donovan L. Olsen
Submitted by:
Chief, Branch

Date: Dec. 24, 2003
Rev.
Design file no.
Drawing Number: 59623
File name:
Plot date:
Plot scale:

Ammunition/Explosives Test Building
ABERDEEN PROVING GROUND
Aberdeen, Maryland

BORING LOCATION PLAN

Sheet Number:
C-3.01
Plate: 1 of 8

RELOCATE ENVIRONMENTAL TESTING MISSION
ABERDEEN PROVING GROUND, MD

SUBSURFACE EXPLORATION NOTES

1. EXPLORATION WAS PERFORMED DURING APRIL 2004.

2. DRILL HOLES (DH) WERE ACCOMPLISHED BY STANDARD PENETRATION TEST PROCEDURE (SPT, ASTM - 1586) USING A 1-3/8"ID SPLIT SPOON SAMPLER. SAMPLE SPOONS WERE ADVANCED BY A 140# HAMMER FALLING 30". THESE HOLES WERE POWER AUGERED BETWEEN SAMPLES UNLESS OTHERWISE INDICATED. BLOW COUNTS SHOWN ARE FOR 0.5' OF DRIVE, UNLESS OTHERWISE INDICATED.

   WH - DENOTES WEIGHT OF HAMMER

3. BLOW COUNTS REQUIRED TO ADVANCE SAMPLE SPOON ARE SHOWN IN COLUMN (a).

4. COLUMN (b) SHOWS THE NATURAL WATER CONTENTS IN PERCENT OF DRY WEIGHT OF THOSE SAMPLES TESTED.

5. SOIL DESCRIPTIONS ARE SHOWN IN COLUMN (c).

6. SOIL DESCRIPTIONS ARE LABORATORY CLASSIFICATIONS BASED ON THE UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D2487/2488), EXCEPT THOSE INDICATED THUS (**), WHICH ARE FIELD INSPECTOR'S CLASSIFICATIONS.

7. GROUNDWATER DEPTHS ARE INDICATED ON THE LOGS AS ∇, ⧗ & ▼ ARE SHOWN IN COLUMN (d). PERTINENT DATA FOR THESE READINGS ARE SHOWN AT THE BOTTOM OF LOG UNDER GROUNDWATER DATA OR ADDITIONAL GROUNDWATER DATA. THESE READINGS MAY VARY DEPENDING UPON SEASONS AND AMOUNT OF RAINFALL.

   NE - INDICATES GROUNDWATER NOT ENCOUNTERED

8. ELEVATIONS SHOWN ON THE BORING LOGS ARE GROUND SURFACE ELEVATIONS AT THE TIME OF EXPLORATION. THEY WERE DETERMINED BY ESTIMATION FROM TOPOGRAPHIC CONTOUR MAPS; DESIGNATED (±).

9. FOR LOCATIONS OF SUBSURFACE EXPLORATIONS, SEE BORING LOCATION PLAN.

STA. RELOCATE ENVIRONMENTAL TESTING MISSIONN
OFFSET: ABERDEEN PROVING GROUND, MD. E
TOP ELEV: 19± COMPLETED: April 26, 2004

DEPTH(ft)	(c)	(d)		(a)	(b)
0.40	Moist, lt. olive brown, silty v. fine SAND w/roots & leaves (SM)				
2.00	Moist, lt. olive brown, poorly graded silty SAND (SM)	▼		2-4-5	
4.50	Wet, lt. olive brown, silty fine SAND (SM)			3-3-4	
7.00	Wet, lt. brownish gray, silty fine SAND w/silt lenses (SM)		5	1-2-5	
9.50	V. moist, grayish brown, silty fine SAND (SM)	∇		3-5-10	
12.00	Wet, lt. olive brown, silty v. fine SAND (SM)		10	2-1-4	
14.50	Wet, lt. olive brown, poorly graded fine SAND w/silt (SP-SM)			4-5-5	
17.00	Wet, strong brown & gray, silty fine SAND (SM)		15	5-7-10	
19.50	Wet, yellowish brown, silty fine SAND (SM)			22-6-5	
	Wet, lt. yellowish brown, poorly graded med. SAND (SP)				

DH-1
GROUNDWATER DATA
∇ WHILE DRILLING: 7.5
▼ ON COMPLETION: 23.0
▼ 24 Hr. READING: 1.1

Fill | Auger | SPT | RB
Cored | 300 lb | Tubex | Hand
Fish Tail | Vibra Core | Water Jet | _

GEO-2 AMMO EXPLOSIVE BLDG.GPJ 5/27/04 10:37

DEPTH(ft)	(c)	(d)		(a)	(b)
	Wet, lt. yellowish brown, poorly graded med. SAND (SP) *(continued from previous page)*			4-5-6	
22.00	Wet, lt. olive brown, poorly graded med. SAND (SP)			3-4-6	
24.50	Wet, yellowish brown, poorly graded med. SAND (SP)		25	4-6-7	
27.00	Wet, lt. olive brown, poorly graded med. SAND (SP)			4-5-6	
29.50	Wet, lt. olive brown, poorly graded med. SAND w/silt & clay lens (SP-SM)		30	2-3-3	
31.50	BOTTOM OF HOLE				
			35		
			40		

STA. RELOCATE ENVIRONMENTAL TESTING MISSIONN
OFFSET: ABERDEEN PROVING GROUND, MD. E
TOP ELEV: 20± COMPLETED: April 27, 2004

DEPTH(ft)	(c)	(d)	Depth scale	(a)	(b)
0.30	Wet, dk. yellowish brown, soft SILT w/roots & twigs (ML)				
	Wet, dk. yellowish brown, soft sandy SILT (ML)			2-2-4	20.3
2.00	Wet, lt. yellowish brown, silty v. fine SAND (SM)			3-5-4	22.9
4.50	Wet, lt. olive brown, sandy SILT (ML)	∇	5	2-3-4	
7.00	V. moist, lt. olive brown, silty fine SAND (SM)			4-4-7	
			10		
10.70	Wet, yellowish brown, silty fine SAND (SM)			4-5-7	
				2-3-6	
		▼	15	5-7-5	
				3-5-8	
19.50	Wet, yellowish brown, poorly graded med. SAND w/silt (SP-SM)				

DH-2
GROUNDWATER DATA
∇ WHILE DRILLING: 5.0
▼ ON COMPLETION: 21.9
▼ 24 Hr. READING: 14.4

Fill | Auger | SPT | RB
Cored | 300 lb | Tubex | Hand
Fish Tail | Vibra Core | Water Jet | _

GEO-2 AMMO EXPLOSIVE BLDG.GPJ 5/27/04 10:37

DEPTH(ft)	(c)	(d)	Elev.	(a)	(b)
	Wet, yellowish brown, poorly graded med. SAND w/silt (SP-SM) *(continued from previous page)*			2-6-10	
22.00	Wet, yellowish brown, poorly graded med-coarse SAND w/silt (SP)	▼		6-5-7	
24.50	Wet, black & strong brown, poorly graded med-coarse SAND w/silt (SP-SM)		25	12-12-13	
27.00	Wet, dk. yellowish brown, poorly graded med. SAND (SP)			6-4-7	
29.50	Wet, dk. yellowish brown, poorly graded med. SAND w/trace of gravel (SP)		30	5-4-7	
30.90	V. moist, yellowish brown, firm sandy SILT (ML)				
31.50	BOTTOM OF HOLE				
			35		
			40		

STA.
OFFSET:
TOP ELEV: 19±

RELOCATE ENVIRONMENTAL TESTING MISSIONN
ABERDEEN PROVING GROUND, MD. E

COMPLETED: April 27, 2004

DEPTH(ft)	(c)	(d)
0.00–2.00	V. moist, yellowish brown, firm SILT w/roots (ML/CL)	
2.00–4.50	V. moist, yellowish brown, firm sandy silty CLAY (CL-ML)	
4.50–7.00	V. moist, yellowish & olive brown, firm sandy SILT (ML)	
7.00–10.50	Wet, yellowish brown, clayey fine sandy silty CLAY (CL-ML)	
10.50–12.00	Moist, yellowish brown, poorly graded fine-med SAND w/silt (SP-SM)	⊻ (10.5)
12.00–13.00	Moist, lt. olive brown, silty fine SAND (SM)	
13.00–14.50	Moist, dk. yellowish brown, soft lean CLAY (CL)	⊻ (13.2)
14.50–18.20	Wet, lt. olive brown, poorly graded med-coarse SAND w/silt (SP-SM)	⊻ (15.1)
18.20–	Wet, lt. olive brown, silty v. fine SAND (SM)	

Depth scale	(a)	(b)
	1-2-2	25.6
	3-6-9	23.7
5	4-5-5	18.1
	2-5-4	22.5
10	4-4-6	
	2-4-4	
15	5-7-6	
	3-3-6	

DH-3
GROUNDWATER DATA
⊻ WHILE DRILLING: 10.5
⊻ ON COMPLETION: 15.1
⊻ 24 Hr. READING: 13.2

Fill | Auger | SPT | RB
Cored | 300 lb | Tubex | Hand
Fish Tail | Vibra Core | Water Jet | _

DEPTH(ft)	(c)	(d)	(a)	(b)
	Wet, lt. olive brown, silty v. fine SAND (SM) *(continued from previous page)*		5-10-11	
22.00	Wet, yellowish brown, poorly graded med. SAND w/ silt (SP-SM)		5-6-8	
24.50	V. moist, yellowish brown, poorly graded med. SAND w/silt (SP-SM)		11-10-12	
28.40	V. moist, brown, soft lean CLAY w/sand (CL)		3-4-5	
29.00	V. moist, yellowish brown, poorly graded med. SAND w/silt (SP-SM)		5-6-7	
31.20	Wet, brown, soft SILT w/sand (ML)			
31.50	BOTTOM OF HOLE			

Depth scale: 25, 30, 35, 40

STA.　　RELOCATE ENVIRONMENTAL TESTING MISSIONN　　**DH-4**

OFFSET:　　ABERDEEN PROVING GROUND, MD.　　E　　1 of 1

TOP ELEV: 14±　　COMPLETED: April 30, 2004

DEPTH(ft)	(c)	(d)	(a)	(b)
0.20	Moist, dk. brown, soft lean CLAY w/sticks & leaves (CL)			38.4
2.00	Moist, yellowish brown, soft lean CLAY (CL)		WH-1-1	22.1
4.50	Moist, yellowish brown, soft-firm lean CLAY (CL)		1-2-4	21.2
6.00	Moist, yellowish brown, firm lean CLAY (CL)	5	5-7-7	20.3
6.50	Moist, dk. yellowish brown, silty fine SAND (SM)	⊻		
	BOTTOM OF HOLE			

DH-4
GROUNDWATER DATA
⊻ WHILE DRILLING: 6.3
ON COMPLETION: NE
24 Hr. READING: NE

Fill　Auger　SPT　RB
Cored　300 lb　Tubex　Hand
Fish Tail　Vibra Core　Water Jet　_

GEO-2 AMMO EXPLOSIVE BLDG.GPJ 5/27/04 10:37

STA. RELOCATE ENVIRONMENTAL TESTING MISSIONN **DH-5**

OFFSET: ABERDEEN PROVING GROUND, MD. E **1 of 1**

TOP ELEV: 17± COMPLETED: April 29, 2004

DEPTH(ft)	(c)	(d)		(a)	(b)
	Moist, brown, silty fine SAND w/grass & roots (SM)			WH/1.5	20.2
2.00	Moist, dk. yellowish brown silty, v. fine SAND (SM/SC)			2-2-2	15.5
4.50	Moist, lt. olive brown, silty fine SAND (SM)		5	3-3-3	12.3
6.50	BOTTOM OF HOLE				

DH-5
GROUNDWATER DATA
WHILE DRILLING: NE
ON COMPLETION: NE
24 Hr. READING: NE

Fill | Auger | SPT | RB
Cored | 300 lb | Tubex | Hand
Fish Tail | Vibra Core | Water Jet | _

GEO-2 AMMO EXPLOSIVE BLDG.GPJ 5/27/04 10:37

STA. RELOCATE ENVIRONMENTAL TESTING MISSIONN **DH-6**

OFFSET: ABERDEEN PROVING GROUND, MD. E **1 of 1**

TOP ELEV: 18± COMPLETED: April 28, 2004

DEPTH(ft)	(c)	(d)		(a)	(b)
	Moist, dk. yellowish brown soft-firm lean CLAY (CL)			WH-2-2	29.6
2.00	Moist, dk. yellowish brown firm lean CLAY (CL)			5-8-9	24.6
4.50	Moist, dk. yellowish brown firm lean CLAY w/trace of sand (CL)		5	3-5-6	23.6
6.50	BOTTOM OF HOLE				

DH-6
GROUNDWATER DATA
WHILE DRILLING: NE
ON COMPLETION: NE
24 Hr. READING: NE

Fill | Auger | SPT | RB
Cored | 300 lb | Tubex | Hand
Fish Tail | Vibra Core | Water Jet | _

GEO-2 AMMO EXPLOSIVE BLDG.GPJ 5/27/04 10:37

STA. RELOCATE ENVIRONMENTAL TESTING MISSIONN **DH-7**

OFFSET: ABERDEEN PROVING GROUND, MD. E **1 of 1**

TOP ELEV: 20± COMPLETED: April 29, 2004

DEPTH(ft)	(c)	(d)		(a)	(b)
2.00	Moist, dk. yellowish brown, SILT w/roots & leaves (ML)			WH-3-5	26.3
4.50	Moist, dk. yellowish brown firm lean CLAY (CL)			3-5-6	35.2
6.50	Moist, dk. yellowish brown firm lean CLAY w/sand lens (CL)	⊻	5	6-9-10	19.0
	BOTTOM OF HOLE				

DH-7
GROUNDWATER DATA
⊻ WHILE DRILLING: 6.1
ON COMPLETION: NE
24 Hr. READING: NE

Fill, Auger, SPT, RB, Cored, 300 lb, Tubex, Hand, Fish Tail, Vibra Core, Water Jet

GEO-2 AMMO EXPLOSIVE BLDG.GPJ 5/27/04 10:37

STA. RELOCATE ENVIRONMENTAL TESTING MISSIONN **DH-8**

OFFSET: ABERDEEN PROVING GROUND, MD. E

TOP ELEV: 22± COMPLETED: April 27, 2004

DEPTH(ft)	(c)	(d)		(a)	(b)
	V. moist, yellowish brown soft lean CLAY w/grass & roots (CL)			WH-1-4	32.0
					48.8
1.00	V. moist, yellowish brown, SILT (ML)				
				3-8-9	20.7
			5		
				5-7-9	18.1
6.50	BOTTOM OF HOLE				

DH-8
GROUNDWATER DATA
WHILE DRILLING: NE
ON COMPLETION: NE
24 Hr. READING: NE

Fill | Auger | SPT | RB
Cored | 300 lb | Tubex | Hand
Fish Tail | Vibra Core | Water Jet | _

STA.	RELOCATE ENVIRONMENTAL TESTING MISSIONN	DH-9
OFFSET:	ABERDEEN PROVING GROUND, MD. E	1 of 1
TOP ELEV: 22±		COMPLETED: April 27, 2004

DEPTH(ft)	(c)	(d)		(a)	(b)
	V. moist, v. dk. grayish brown soft lean CLAY w/leaves, twigs & roots (CL)				
0.70	V. moist, dk. yellowish brown soft lean CLAY (CL)			1-1-1	26.1
2.00	V. moist, dk. yellowish brown firm lean CLAY (CL)			4-4-8	23.2
			5	5-7-9	22.4
6.10	Moist, dk. yellowish brown soft SILT (ML)				
6.50	BOTTOM OF HOLE				

DH-9
GROUNDWATER DATA
WHILE DRILLING: NE
ON COMPLETION: NE
24 Hr. READING: NE

Fill, Auger, SPT, RB, Cored, 300 lb, Tubex, Hand, Fish Tail, Vibra Core, Water Jet, _

GEO-2 AMMO EXPLOSIVE BLDG.GPJ 5/27/04 10:37

APPENDIX C

Soil Test Results

LABORATORY TEST RESULTS

PROJECT: Relocate Environmental Testing Mission **DATE:** May.2004

AREA: Aberdeen Proving Ground, MD

TEST: Natural Moisture Contents (ASTM D2216)

Hole No.	Sample No.	Depth (ft.)	Moisture Content, %
DH-2	Jar-3	2.5-4.0	22.9
DH-3	Jar-1	0.0-1.5	25.6
DH-3	Jar-2	2.5-4.0	23.7
DH-3	Jar-3	5.0-6.5	18.1
DH-3	Jar-4	7.5-9.0	22.5
DH-4	Jar-1	0.0-0.2	38.4
DH-4	Jar-2	0.2-1.5	22.1
DH-4	Jar-3	2.5-4.0	21.2
DH-4	Jar-4	5.0-6.0	20.3
DH-5	Jar-1	0.0-1.5	20.2
DH-5	Jar-2	2.5-4.0	15.5
DH-5	Jar-3	5.0-6.5	12.3
DH-6	Jar-1	0.0-1.5	29.6
DH-6	Jar-2	2.5-4.0	24.6
DH-6	Jar-3	5.0-6.5	23.6
DH-7	Jar-1	0.0-1.5	26.3
DH-7	Jar-2	2.5-4.0	35.2
DH-7	Jar-3	5.0-6.5	19.0
DH-8	Jar-1	0.0-1.0	32.0
DH-8	Jar-2	1.0-1.5	48.8
DH-8	Jar-3	2.5-4.0	20.7
DH-8	Jar-4	5.0-6.5	18.1
DH-9	Jar-2	0.7-1.5	26.1
DH-9	Jar-3	2.5-4.0	23.2
DH-9	Jar-4	5.0-6.1	22.4

LABORATORY TEST RESULTS

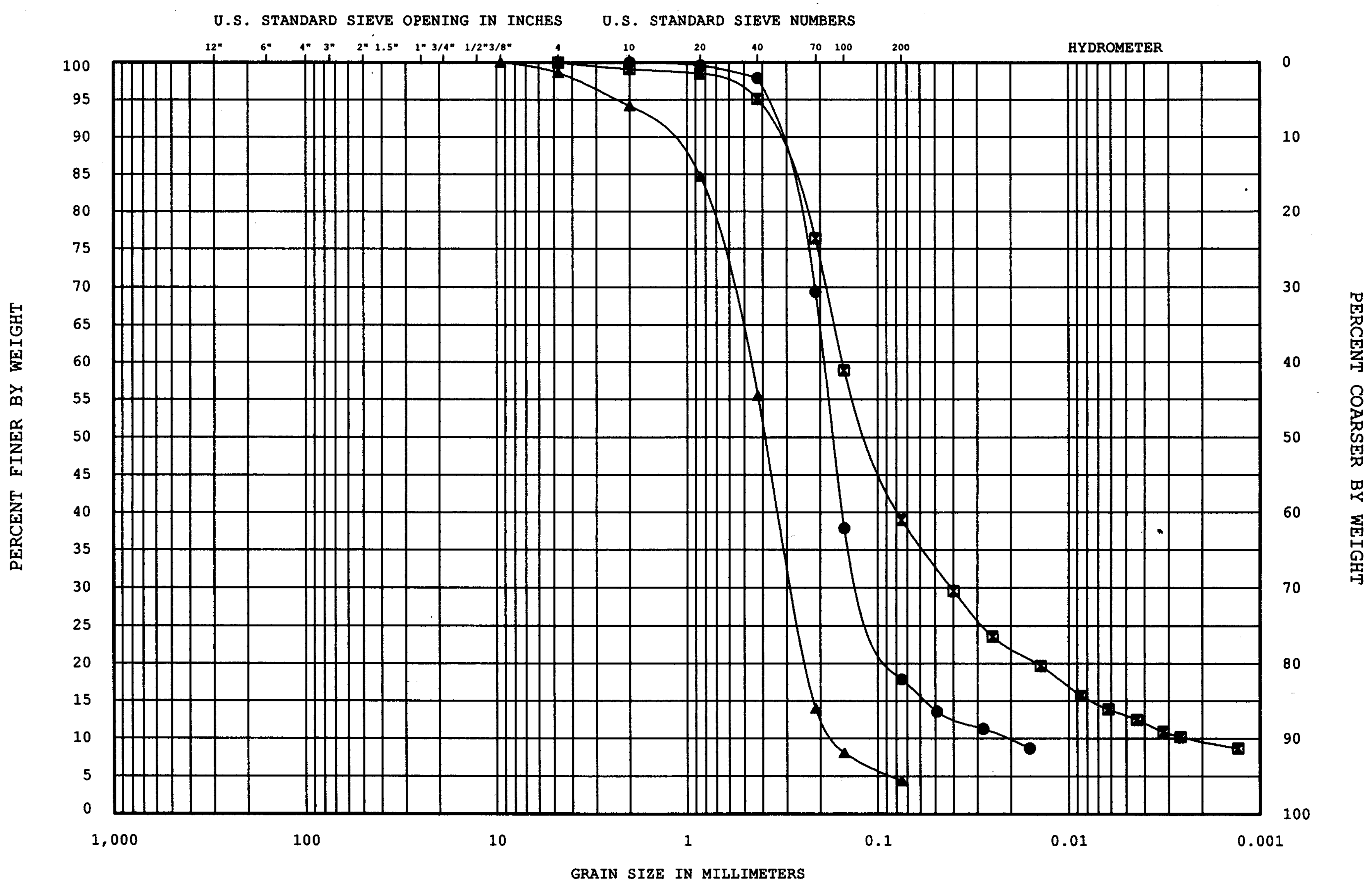
PROJECT: Relocate Environmental Testing Mission **DATE:** May.2004

AREA: Aberdeen Proving Ground, MD

TEST: Natural Moisture Contents (ASTM D 2216) & Atterberg Limits (ASTM D 4318)

Hole No.	Sample No.	Depth (m)	Moisture Content, %	LL	PL	PI	Classification	Symbol
DH-2	Jar-2	0.3-1.5	20.3		NP		Silt	(ML)
DH-2	Jar-3	2.5-4.0	22.9					
DH-3	Jar-1	0.0-1.5	25.6	36	24	12	Lean Clay	(CL)
DH-3	Jar-2	2.5-4.0	23.7	26	19	7	Silty Clay	(CL-ML)
DH-3	Jar-3	5.0-6.5	18.1	22	19	3	Silt	(ML)
DH-3	Jar-4	7.5-9.0	22.5	22	18	4	Silt	(ML)
DH-4	Jar-1	0.0-0.2	38.4					
DH-4	Jar-2	0.2-1.5	22.1	28	21	8	Lean Clay	(CL)
DH-4	Jar-3	2.5-4.0	21.2					
DH-4	Jar-4	5.0-6.0	20.3					
DH-5	Jar-1	0.0-1.5	20.2					
DH-5	Jar-2	2.5-4.0	15.5					
DH-5	Jar-3	5.0-6.5	12.3					
DH-6	Jar-1	0.0-1.5	29.6	35	24	11	Lean clay	(CL)
DH-6	Jar-2	2.5-4.0	24.6					
DH-6	Jar-3	5.0-6.5	23.6					
DH-7	Jar-1	0.0-1.5	26.3	37	25	12	Silt	(ML)
DH-7	Jar-2	2.5-4.0	35.2	34	23	11	Lean clay	(CL)
DH-7	Jar-3	5.0-6.5	19.0					
DH-8	Jar-1	0.0-1.0	32.0					
DH-8	Jar-2	1.0-1.5	48.8	32	24	8	Silt	(ML)
DH-8	Jar-3	2.5-4.0	20.7					
DH-8	Jar-4	5.0-6.5	18.1					
DH-9	Jar-2	0.7-1.5	26.1					
DH-9	Jar-3	2.5-4.0	23.2					
DH-9	Jar-4	5.0-6.1	22.4					

Note: The Atterberg Limits test is only performed on minus No. 40 material portion of a sample and does not represent the entire sample. Refer to the Visual Classification or the Gradation Analysis for the complete classification.



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-2	0.4-1.5	SILTY SAND	SM				
—⊠—	Jar-4	5.0-6.5	SILTY SAND	SM				
—▲—	Jar-11	22.5-24.0	POORLY GRADED SAND	SP				
— —								

Remarks:

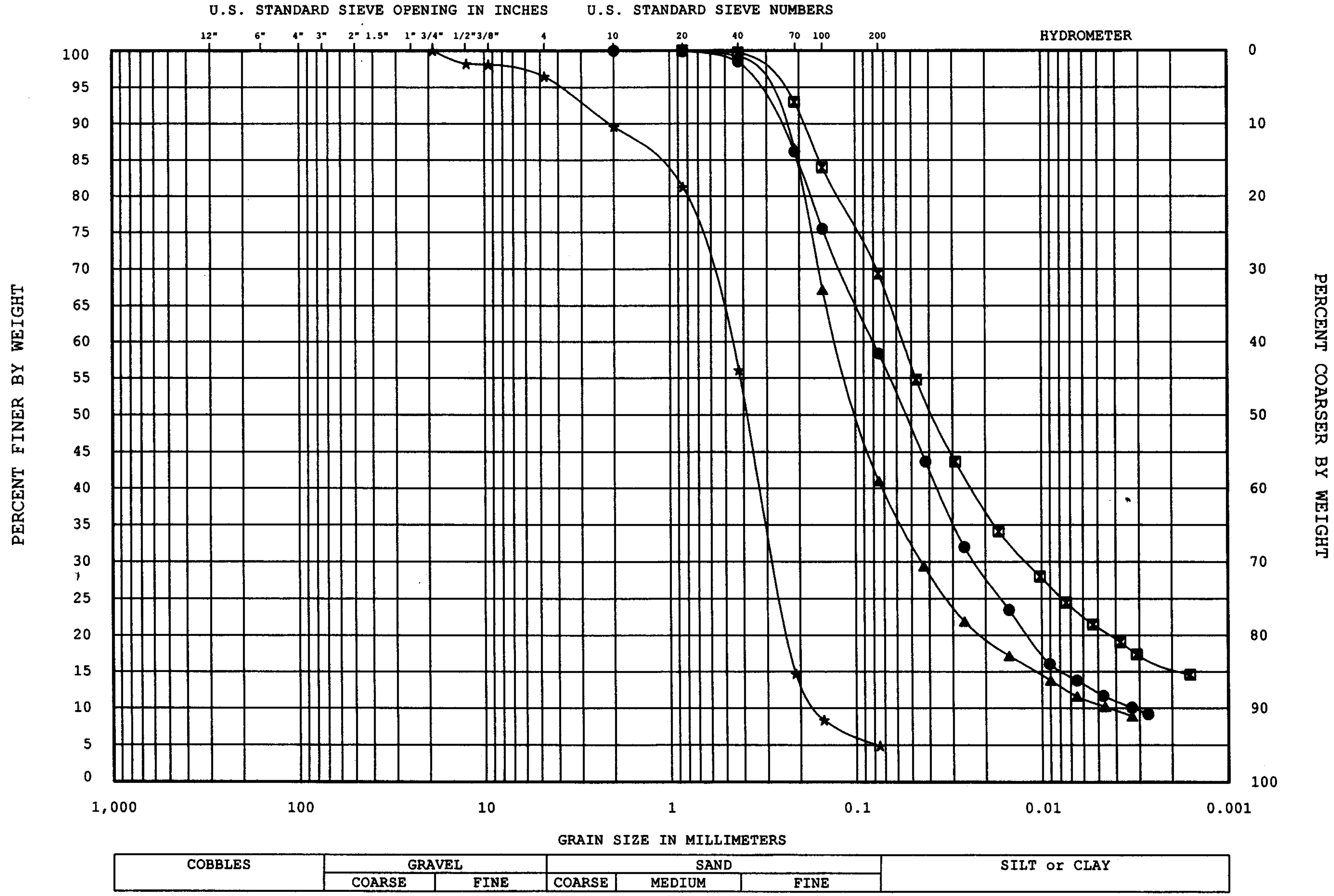
ENG FORM ENG2087-NO ATTSRELOCATE ENVIRO TEST MISSION, APG.GPJ **GRADATION CURVES** TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Relocate Environmental Testing Mission*

AREA: *Aberdeen Proving Ground, MD*

BORING NO.: *DH-1*

DATE: *May 2004*



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-2	0.3-1.5	SANDY SILT	ML	20.3	NP	NP	NP
—⊠—	Jar-4	5.0-6.5	SANDY SILT	ML				
—▲—	Jar-7	12.5-14.0	SILTY SAND	SM				
—★—	Jar-11	22.5-24.0	POORLY GRADED SAND	SP				

Remarks:

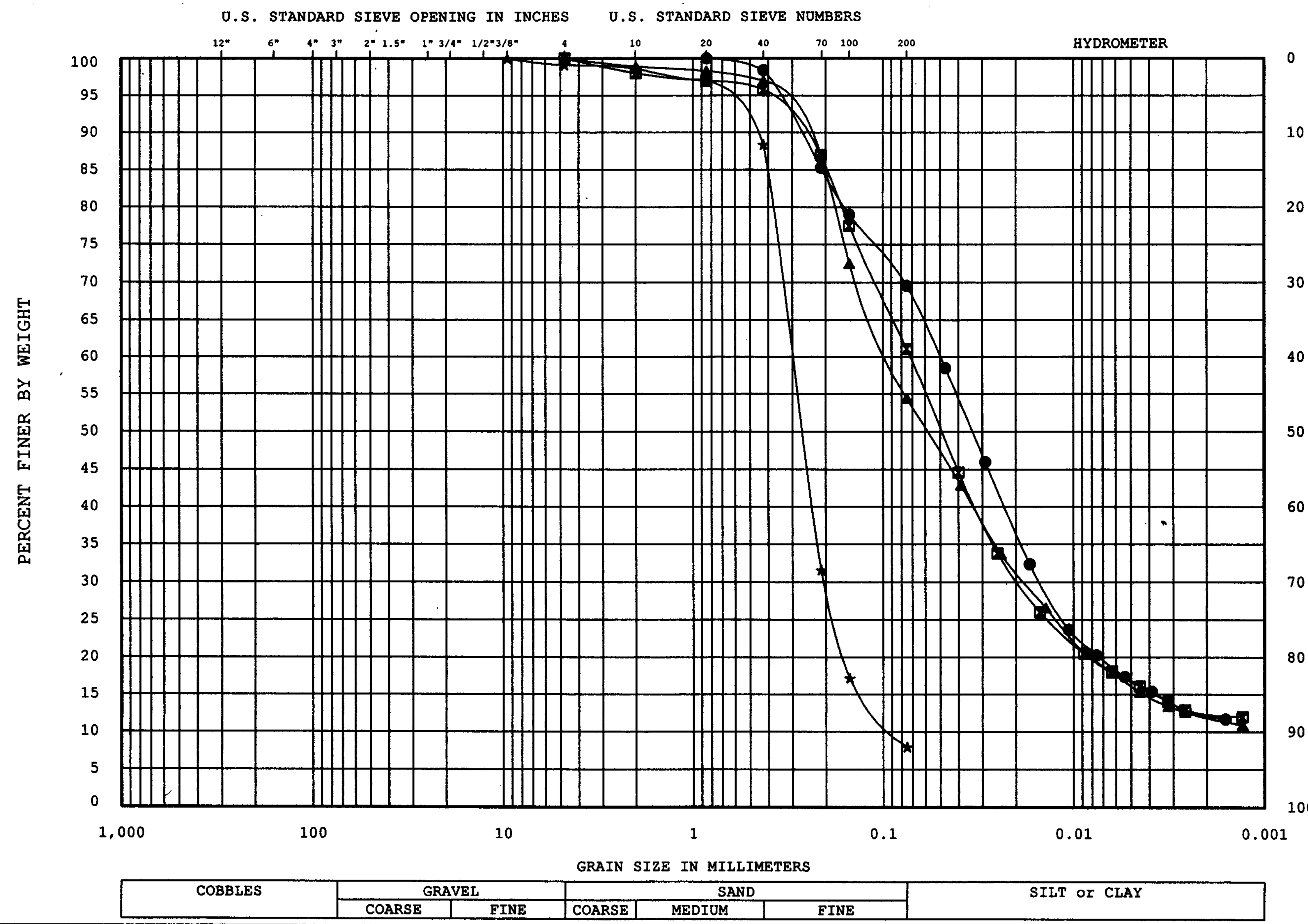
PROJECT: *Relocate Environmental Testing Mission*

AREA: *Aberdeen Proving Ground, MD*

BORING NO.: *DH-2*

DATE: *May 2004*

ENG FORM ENG2087RELOCATE ENVIRO TEST MISSION, APG.GPJ **GRADATION CURVES** TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-2	2.5-4.0	SANDY SILTY CLAY	CL-ML	23.7	26	19	7
—⊠—	Jar-3	5.0-6.5	SANDY SILT	ML	18.1	22	19	3
—▲—	Jar-4	7.5-9.0	SANDY SILTY CLAY	CL-ML	22.5	22	18	4
—★—	Jar-5	10.5-11.5	POORLY GRADED SAND with SILT	SP-SM				

Remarks:

ENG FORM ENG2087RELOCATE ENVIRO TEST MISSION, APG.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Relocate Environmental Testing Mission*

AREA: *Aberdeen Proving Ground, MD*

BORING NO.: *DH-3*

DATE: *May 2004*

APPENDIX D

Pavement Design Calculations
Pavement Details

DESIGN OF AGGREGATE SURFACED ROADS AND AIRFIELDS

1. Purpose

This manual presents the procedures for design of aggregate surfaced roads and airfields.

2. Scope

This manual presents criteria for determining the thickness, material, and compaction requirements for all classes of aggregate surfaced roads and for Class I, II, and III airfields at US Army installations. Road classes are defined in TM 5-822-2, and airfield classes are defined in TM 5-803-4. Class IV Army airfields would normally be paved. Use of the term roads includes roads, streets, open storage areas, and parking areas. Use of the term airfields includes heliports, runways, taxiways, and parking aprons. Design requirements are presented for frost and nonfrost areas.

3. References

Publications cited in this manual are listed in appendix A.

4. Design of aggregate surfaced roads

a. Procedures. The thickness design of aggregate surfaced roads is similar to the design of flexible pavement roads as contained in TM 5-822-5. This procedure involves assigning a class to the road being designed based upon the number of vehicles per day. A design category is then assigned to the traffic from which a design index is determined. This design index is used with figure 1 to select the thickness (minimum of 4 inches) of aggregate required above a soil with a given strength expressed in terms of California Bearing Ratio (CBR) for nonfrost areas or in terms of a frost area soil support index (FASSI) in frost areas.

b. Classes of roads. The classes of aggregate surfaced roads vary from A to G. Selection of the proper class depends upon the traffic intensity and is determined from table 1.

c. Design index. The design of gravel roads will be based on a design index, which is an index representing all traffic expected to use the road during its life. The design index is based on typical magnitudes and compositions of traffic reduced to equivalents in terms of repetitions of an 18,000-pound single-axle, dual-wheel load. For designs involving rubber-tired vehicles, traffic is classified in three groups as follows:

Group 1. Passenger cars and panel and pickup trucks.

Group 2. Two-axle trucks.

Group 3. Three-, four-, and five-axle trucks.

Traffic composition will then be grouped in the following categories:

Category I. Traffic composed primarily of passenger cars, panel and pickup trucks (Group 1 vehicles), and containing not more than 1 percent two-axle trucks (Group 2 vehicles).

Category II. Traffic composed primarily of passenger cars, panel and pickup trucks (Group 1 vehicles), and containing as much as 10 percent two-axle trucks (Group 2 vehicles). No trucks having three or more axles (Group 3 vehicles) are permitted in this category.

Category III. Traffic containing as much as 15 percent trucks, but with not more than 1 percent of the total traffic composed of trucks having three or more axles (Group 3 vehicles).

Category IV. Traffic containing as much as 25 percent trucks, but with not more than 10 percent of the total traffic composed of trucks having three or more axles (Group 3 vehicles).

Category IVA. Traffic containing more than 25 percent trucks or more than 10 percent trucks having three or more axles (Group 3 vehicles).

d. Tracked vehicles and forklift trucks. Tracked vehicles having gross weights not exceeding 15,000 pounds and forklift trucks having gross weights not exceeding 6,000 pounds may be treated as two-axle trucks (Group 2 vehicles) in determining the design index. Tracked vehicles having gross weights exceeding 15,000 pounds but not 40,000 pounds and forklift trucks having gross weights exceeding 6,000 pounds but not 10,000 pounds may be treated as Group 3 vehicles in determining the design index. Traffic composed of tracked vehicles exceeding 40,000-pound gross weight and forklift trucks exceeding 10,000-pound gross weight has been divided into the following three categories:

Maximum Vehicle Gross Weight, pounds

Category	Tracked Vehicles	Forklift Trucks
V	60,000	15,000
VI	90,000	20,000
VII	120,000	35,000

e. Design index. The design index to be used in designing a gravel road for the usual pneumatic-tired vehicles will be selected from table 2.

Table 1. Criteria for selecting aggregate surface road class.

Road Class	Number of Vehicles per day
A	10,000
B	8,400 - 10,000
C	6,300 - 8,400
D	2,100 - 6,300
E	210 - 2,100
F	70 - 210
G	under 70

Table 2. Design index for pneumatic-tired vehicles.

Class	Design Index			
	Category I	Category II	Category III	Category IV
A	3	4	5	6
B	3	4	5	6
C	3	4	4	6
D	2	3	4	5
E	1	2	3	4
F	1	1	2	3
G	1	1	1	2

Table 3. Design index for tracked vehicles and forklift trucks.

Traffic Category	Number of Vehicles per Day (or Week as indicated)							
	500	200	100	40	10	4	1	1 Per Week
V	8	7	6	6	5	5	5	—
VI	—	9	8	8	7	6	6	5
VII	—	—	10	10	9	8	7	6

often has greater impact than localized failure on the hardstand itself. Since these areas will almost certainly be subjected to more frequent and heavier loads than the hardstand, the design index used for the primary road should be used for entrances and exits to the hardstand. In the case of large hardstands having multiple use and multiple entrances and exits, consideration should be given to partitioning and using different classes of design. The immediate benefits that would accrue include economy through elimination of overdesign in some areas and better organization of vehicles and equipment.

i. Thickness criteria (nonfrost areas). Thickness requirements for aggregate surfaced roads are determined from figure 1 for a given soil strength and design index. The minimum thickness requirement will be 4 inches. Figure 1 will be entered with the CBR of the subgrade to determine the thickness of aggregate required for the appropriate design index. The thickness determined from the figure may be constructed of compacted granular fill for the total depth over the natural subgrade or in a layered system of granular fill (including subbases) and compacted subgrade for the same total depth. The layered section should be checked to ensure that an adequate thickness of material is used to protect the underlying layer based on the CBR of the underlying layer. The granular fill may consist of base and subbase material provided the top 6 inches meet the gradation requirements in paragraph 8.

5. Design of aggregate surfaced airfields

The thickness design of aggregate surfaced airfields is similar to the design of flexible pavement airfields as contained in TM 5-825-2. This procedure involves assigning a class to the airfield based upon the aircraft controlling the design. Having selected the class of airfield, the design is accomplished using figures 2 through 4.

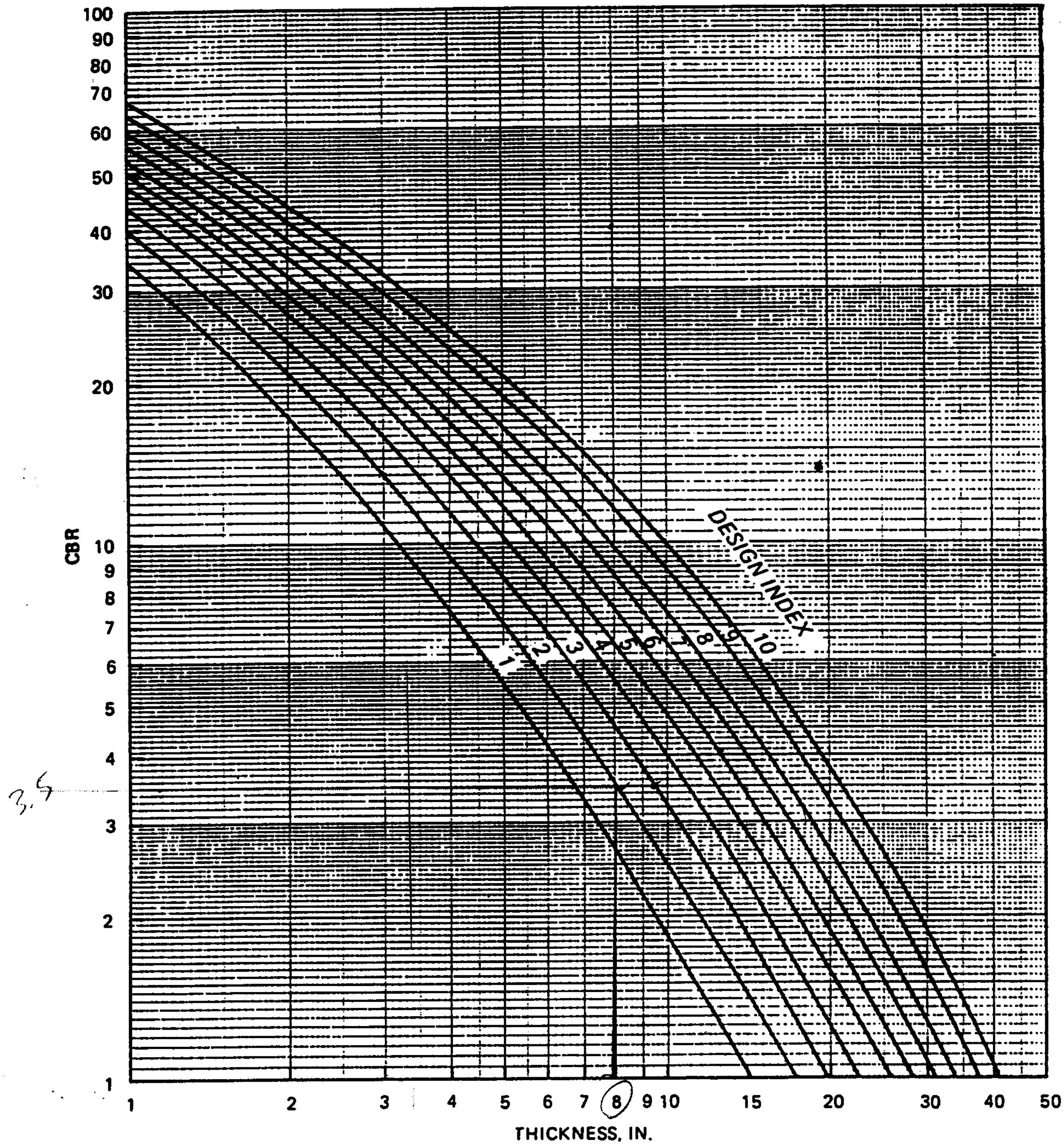
a. Classes of airfields. There are four classes of Army airfields. These are Classes I–IV, although only Classes I–III are considered candidates for aggregate surfacing. Each class of airfield is designed for a standard loading condition and pass level as defined in TM 5-803-4. Where necessary, airfields may be designed for loads and pass levels other than the standard, and the criteria herein provide thicknesses for varying pass and load levels.

b. Traffic areas. Army airfields are divided into traffic areas for design purposes. Type B traffic areas consist of taxiways, the first 1,000 feet of runway ends, and aprons. Type C traffic areas are the interior portions of the runway (between the 1,000 foot runway ends).

c. Thickness criteria (nonfrost areas). Thickness requirements for aggregate surfaced airfields are determined from figures 2 through 4 for types B and C traffic areas. Thicknesses for type B areas are determined directly from the curves, and type C traffic areas are designed using 75 percent of the load used to design type B traffic areas. The minimum thickness requirement for all cases will be 4 inches. The figure for the appropriate airfield class will be entered with the subgrade CBR to determine the thickness required for a given load and pass level. The thickness determined from the figure may be constructed of compacted granular fill for the total depth over the natural subgrade or in a layered system of granular fill and compacted subgrade for the same total depth. The layered section should be checked to ensure that an adequate thickness of material is used to protect the underlying layer based upon the CBR of the underlying layer. The granular fill may consist of base and subbase material provided the top 6 inches meet the gradation requirements of paragraph 8.

6. Design CBR for select materials and subbases

Design CBR values and materials requirements for select materials and subbases are to be selected in accordance with TM 5-825-2 except as modified in table 4.



DESIGN CURVES FOR
GRAVEL SURFACED ROADS

Figure 1. Thickness design curves for aggregate surfaced roads.

f. Roads for tracked vehicles. Roads sustaining traffic of tracked vehicles weighing less than 40,000 pounds, and forklift trucks weighing less than 10,000 pounds, will be designed in accordance with the pertinent class and category from table 2. Roads sustaining traffic of tracked vehicles, heavier than 40,000 pounds, and forklift trucks heavier than 10,000 pounds, will be designed in accordance with the traffic intensity and category from table 3.

g. Design life. The life assumed for design is 25 years. For a design life less than 5 years, the design indexes in tables 2 and 3 may be reduced by one. Design indexes below three should not be reduced.

h. Entrances, exits, and segments. Regardless of the design class selected for hardstands, special consideration should be given to the design of approach roads, exit roads, and other heavily trafficked areas. Failure or poor performance in these channelized traffic areas

RIGID PAVEMENT DESIGN
(INTERIOR FLOOR SLABS)

PROJECT: Relocation Bldg 690

LOCATION: APG, Maryland Virginia DATE: 30 April 2004

Design By: DLF Checked By: OEF

SCOPE: Design of concrete floor slabs-on-grade subject to vehicular loads and to high stationary live loads (loads imposed by movable items).

REFERENCE: TM 5-809-12, Concrete Floor Slabs-on-Grade Subjected to Heavy Loads.
TM 5-822-5, Pavement Design for Roads, Streets, Walks, and Open Storage Areas

I. NONREINFORCED STRENGTH DESIGN:

1. Traffic Volume(s):

a. Category of Traffic (page 3-1 & paragraph 3-2, Traffic Distribution). (per customer, 6kip forklift 4 passes per day & 15 kip forklift 2 passes per week)

b. Category	Largest Maximum Axle Load (kips)*	Maximum Load Capacity (kips)	Maximum Operations/Day
I	10	2 to 4	4 per day
II	15	4 to 6	2 per week
III	25	6 to 10	
IV	36	10 to 16	
V	43	16 to 20	
VI	120	20 to 52	

Note: Data from Facilities Engineer's office and the Using Agency.

2. Design Index: Design index = **UP TO 5** (page 5-1, Table 3, Traffic Categories for Design Index. This table good for all Cat. I and II forklifts, but only up to 5 passes of a Cat III forklift; i.e., 25-kip max axle-load forklift.)

3. Modulus of Subgrade Reaction (K) = **100 pci** (Based on correlation). However, based Fig 9-1, TM 5-822-5, the equivalent K at top of 6 inch base course is **150 pci**

NAB FROM 1358a
Rev. AUGUST 1994

4. Concrete 28-day Flexural Strength (P) = **635** psi (5000 psi 28-day compressive strength).

Based on compressive strength: P = (7.5 to 10) x SQRT (Compressive Strength)
Ref: p.5, Design & Control of Conc Mixtures, PCA, 13th Edition
Use 7.5 to 8 for gravels and 9 to 10 for crushed stone.
P = 9 x SQRT (5000 psi) = **637** psi.

5. Nonreinforced Pavement Thickness:

a. Theoretical nonreinforced pavement thickness (h_d) = **6** inches (to nearest 0.1 inch).

(1) Categories I, II, III: Design index curves, Figure 5-1, Design Curves for Concrete Floor Slabs, page 5-2. These curves are good for all Cat. I and II forklifts, but only up to 5 passes of a Cat III forklift; i.e., 25-kip max axle-load forklift.). This yields h_d = 6 inches.

b. Nonreinforced pavement thickness = **6** inches.

II. REINFORCED STRENGTH DESIGN:

1. Purpose: To increase the size of floor slab panels between joints or to decrease slab thickness requirements.

2. Graphic solution (nomogram):

Nomogram: Page 5-9, Figure 5-4, Design Thickness for Reinforced Floor Slabs.

(1) Per drawings, structural engineer using 6X6 W2.9 X W2.9 = 0.058 sqin per foot of steel. S% = 100 * (0.058 / (6" *12"/')) = .08 percent steel

(2) Maximum allowable joint spacing per nomogram = 40 feet.

Check: Maximum Slab Length (Maximum Joint Spacing):

$L=\{0.00047\ h_r\ (f_s S)^2\}^{1/3}$ Ref Eqn 5-2, para 5-7a(3)d, page 5-16, TM 5-809-12
L = 38.6 ft (say 40') where: hr = 6" (reinf slab thickness)
fs = 56,000 psi (steel yield strength)
S = % reinf steel
= .058 sq in per ft / 6" x 12"/') 100%
= .08%

III. FINAL PAVEMENT SECTION:

1. **Interior Concrete Pavement Section**:

6" Concrete (**635** psi flexural strength @ 28 days)
with 6" **x** 6" **- W2.9 x W2.9 WWM** placed **2.5**" below the concrete surface.
4" DGA
10cv-mil polyethylene sheeting (Vapor Barrier)
4" Capillary water barrier Base Course

Maximum allowable length of reinforced pavement slabs = **40** feet.

2. Reinforcing Around Bollards, Columns and Other Projections Through Pavement Surface: To minimize cracking around projections and to hold these cracks together, place the following additional reinforcing at the corners of all projections, with a minimum of four sets of bars around circular projections greater than 6 inches in diameter:

2 No. 4 Reinforcing Bars, each 4 feet long, Spaced 4 inches apart.
Place bars at the mid-point of the slab

3. Dowel Size and Spacing: (Ref Table 5-3, Dowel Size and Spacing, page 5-23)

¾ inch Dia. Bar, 16 inches long (min)
Spaced 12 inches (max) center to center.

IV. MAXIMUM ALLOWABLE STATIONARY LIVE LOAD:

1. Concrete floor slab thickness = **6** inches (from Step III-1a).

2. 28-day Flexural strength of concrete (P) = **635** psi. (from step I-4)

3. Stationary live load = **1002** psf (Table 3-1, Maximum Allowable Stationary Live Load, page 3-3).

4. Modulus of Subgrade Reaction (K) = **150** pci. (from step I-3)

5. Constant factor = **1.2** (Table 3-1, page 3-3).

6. Maximum stationary live load = 1002 x 1.2 = **1202** psf
(Step IV3) x (Step IV5)

Note: The potential consolidation of underlying soils shall be evaluated to determine that no detrimental settlements will occur before specifying stationary live loads greater than 500 psf.

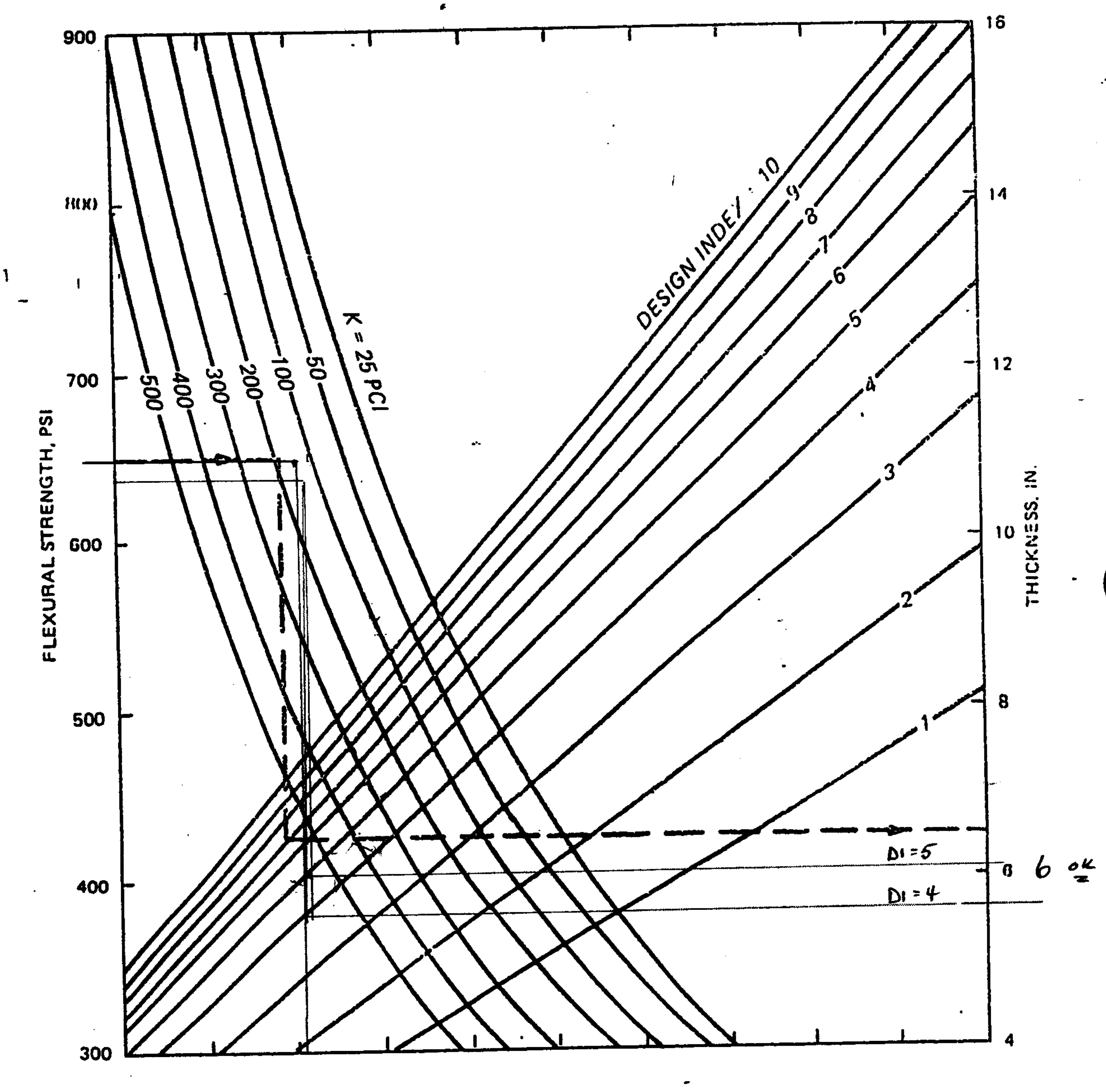
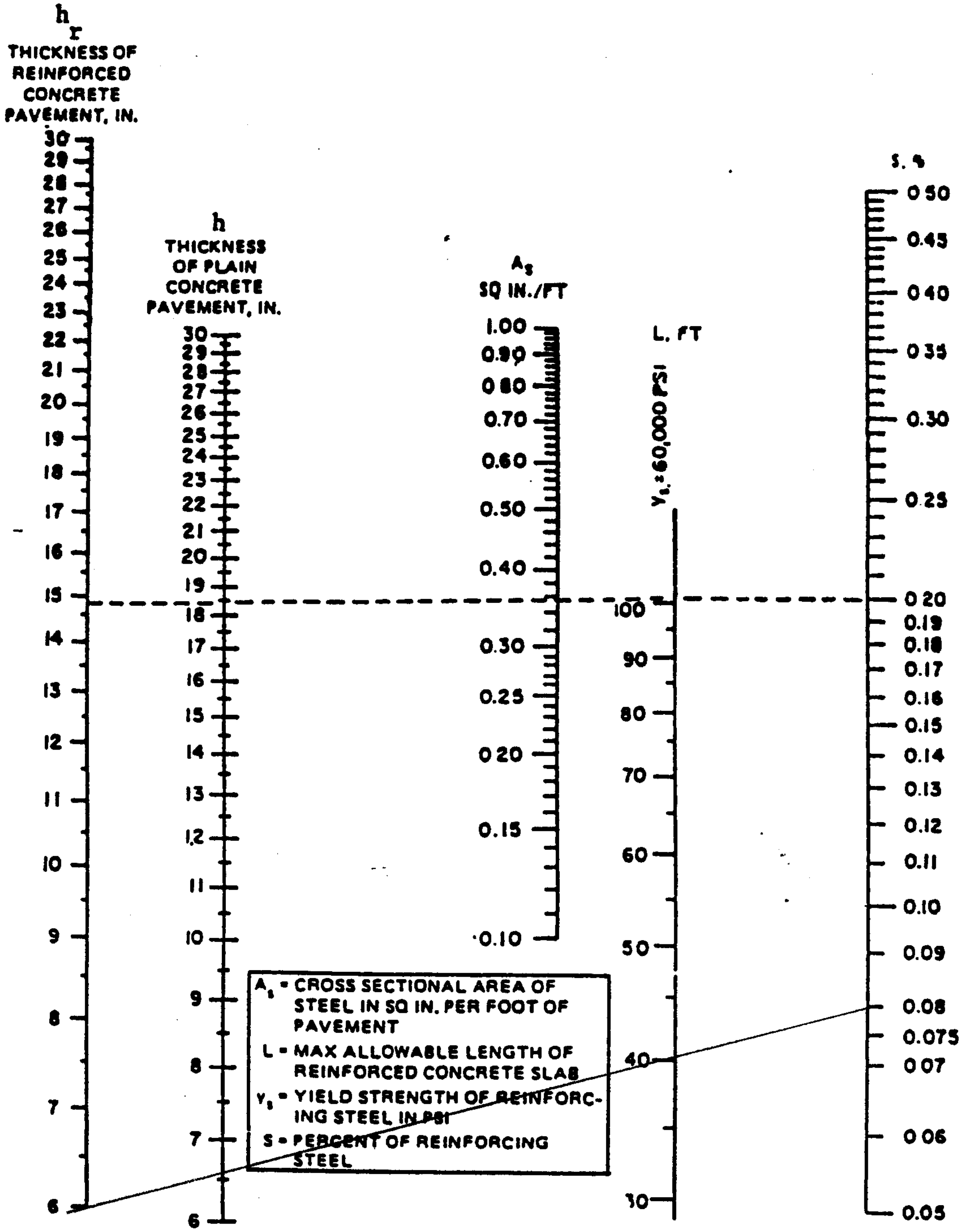


Figure 5-1. Design curves for concrete floor slabs by design index.



REINFORCED CONCRETE PAVEMENT DESIGN

NOTE: MINIMUM THICKNESS OF REINFORCED CONCRETE FLOOR SLABS WILL BE 6 IN.

Figure 5-4. Design thickness for reinforced floor slabs.

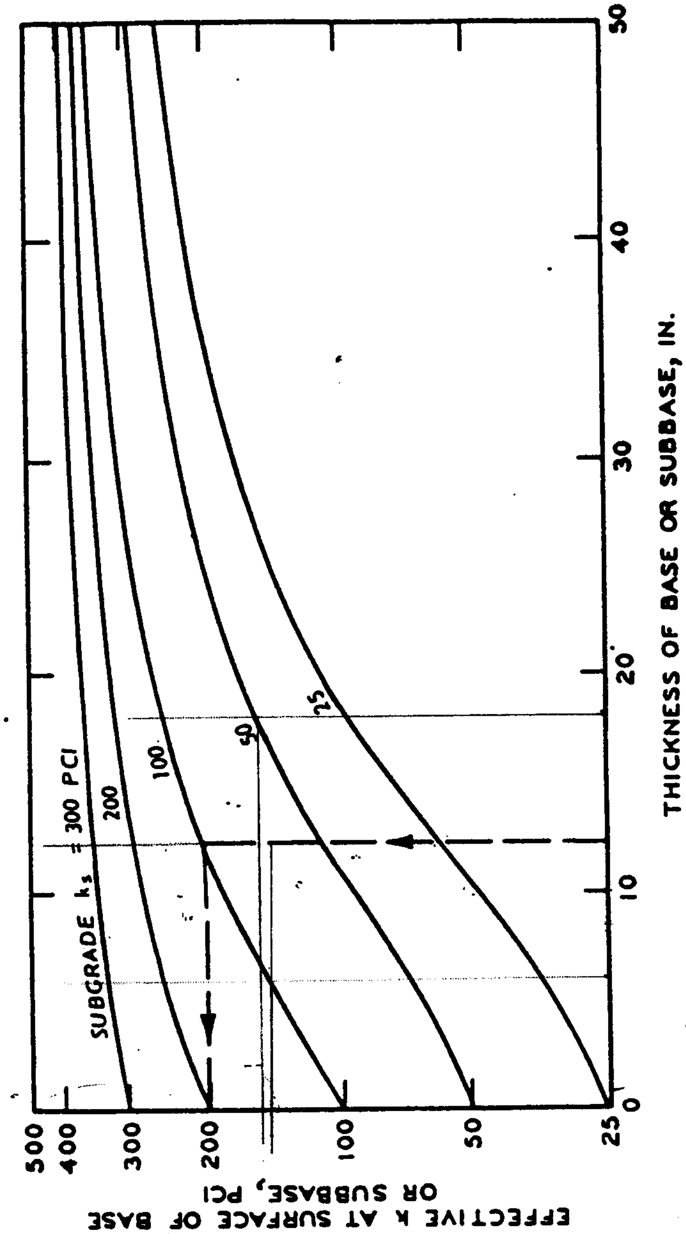


Figure 9-1. Effect of Base-Course Thickness on Modulus of Soil Reaction.

Assume Subgrade Soils as follow:

SC @ 17% w @ Less Than 90% Dry Density ∴ use K_{sub} = 100 pci ∴ w/ 6" Base K_{ef} = 150 pci

or

CL/ML @ 21% w @ less Than 90% Dry Density ∴ use K = 50 pci

∴ require Subgrade STAB.

∴ 12" + 6" = 18" Base

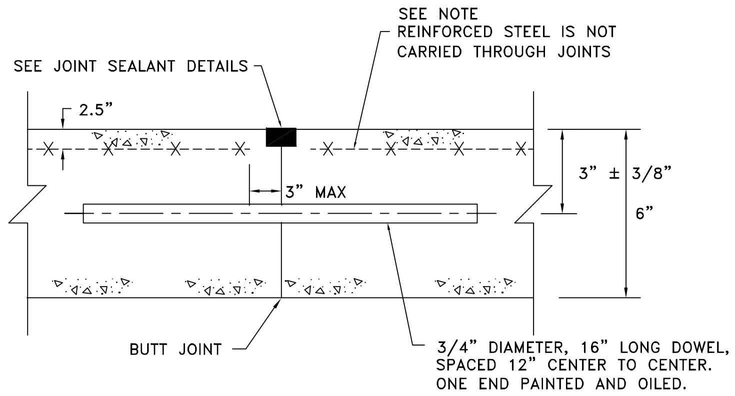
sub. stab CWB

∴ K_{ef} = 150 pci

Table 4-1. Typical values of modulus of subgrade reaction

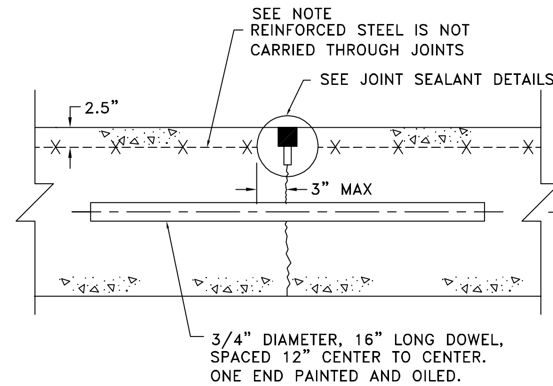
Types of Materials	Modulus of Subgrade Reaction, k, in lb/in^3 for Moisture Contents of							
	1 to 4%	5 to 8%	9 to 12%	13 to 16%	17 to 20%	21 to 24%	25 to 28%	Over 29%
Silts and clays Liquid limit > 50 (OH, CH, MH)	--	175	150	125	100	75	50	25
Silts and clays Liquid limit < 50 (OL, CL, ML)	--	200	175	150	125	100	75	50
Silty and clayey sands (SM & SC)	300	250	225	200	150	--	--	--
Gravelly sands (SW & SP)	300+	300	250	--	--	--	--	--
Silty and clayey gravels (GM & GC)	300+	300+	300	250	--	--	--	--
Gravel and sandy gravels (GW & GP)	300+	300+	--	--	--	--	--	--

NOTE: k values shown are typical for materials having dry densities equal to 90 to 95 percent of the maximum CE 55 density. For materials having dry densities less than 90 percent of maximum CE 55 density, values should be reduced by 50 lb/in^3, except that a k of 25 lb/in^3 will be the minimum used for design.



REINFORCED CONSTRUCTION JOINT

N.T.S.



REINFORCED CONTRACTION JOINT

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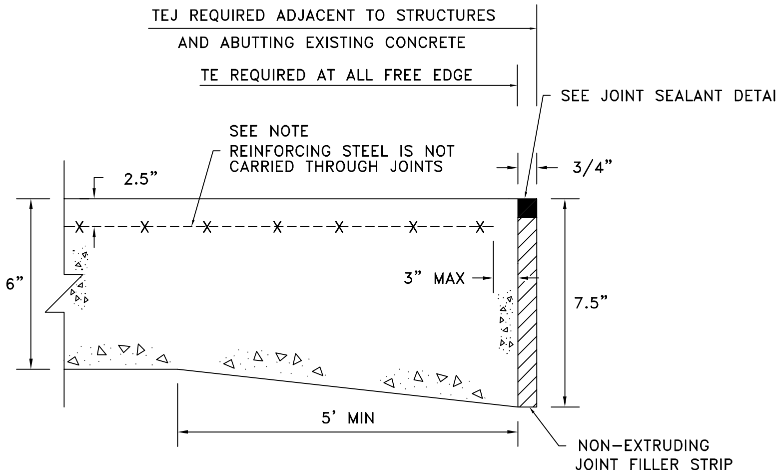
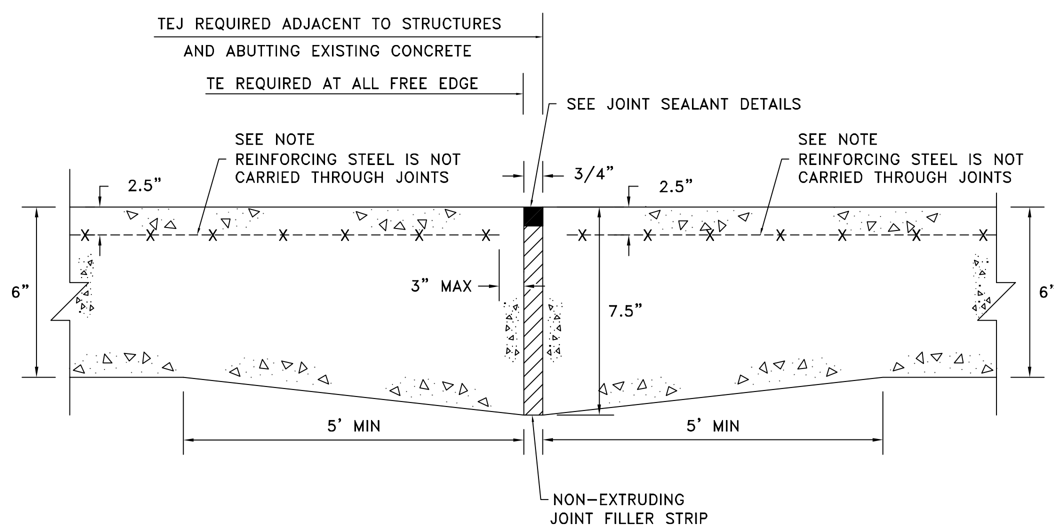


REINFORCED THICKENED-EDGE (TE) JOINT
& THICKENED-EDGE EXPANSION JOINT (TEJ)

N.T.S.



REINFORCED THICKENED-EDGE EXPANSION JOINT (EJ)(TEJ)

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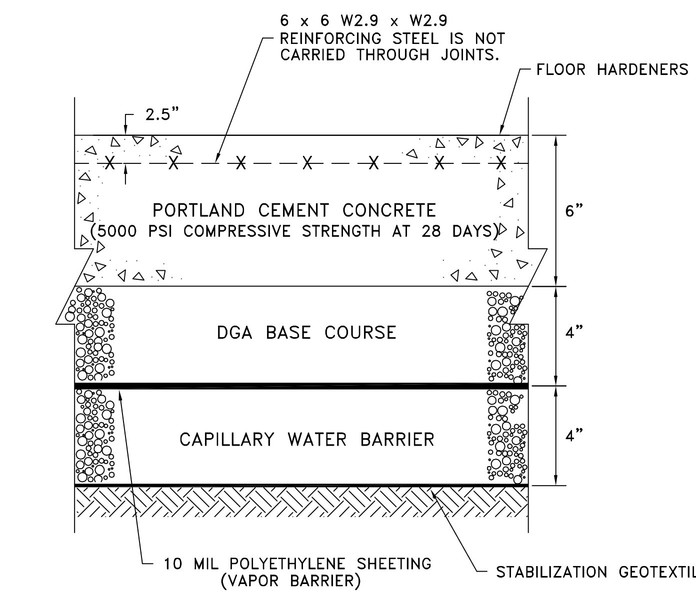


(FLOOR SLABS-ON-GRADE SUBJECT TO VEHICULAR TRAFFIC)

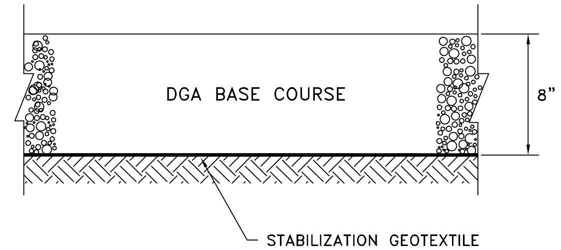
NOTES:

1. PRIOR TO INSTALLATION OF VAPOR BARRIER, CHOKE OFF CAPILLARY WATER BARRIER WITH 1/2" OF ASTM C33 CONCRETE SAND.

2. WHERE SUBGRADE STABILIZATION IS REQUIRED AS DEFINED IN SPECIFICATION SECTIONS 02300 & 02722, THE STABILIZATION GEOTEXTILE SHALL BE PLACED BENEATH THE SUBGRADE STABILIZATION LAYER; OTHERWISE, THE STABILIZATION GEOTEXTILE SHALL BE PLACED DIRECTLY BENEATH THE CAPILLARY WATER BARRIER.

REINFORCED INTERIOR
CONCRETE PAVEMENT SECTION

N.T.S.



NOTE:
WHERE SUBGRADE STABILIZATION IS REQUIRED AS DEFINED IN SPECIFICATION SECTIONS 02300 & 02722, THE STABILIZATION GEOTEXTILE SHALL BE PLACED BENEATH THE SUBGRADE STABILIZATION LAYER; OTHERWISE, THE STABILIZATION GEOTEXTILE SHALL BE PLACED DIRECTLY BENEATH THE DGA BASE COURSE.

GRAVEL ROADWAY SECTION

N.T.S.

NOTE: REFERENCE REINFORCED INTERIOR CONCRETE PAVEMENT SECTION DETAIL FOR REINFORCEMENT REQUIREMENTS.

US Army Corps of Engineers
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ABERDEEN PROVING GROUND MARYLAND
AMMUNITION/EXPLOSIVES TEST BUILDING
PAVING AND JOINT DETAILS

Sheet Number:

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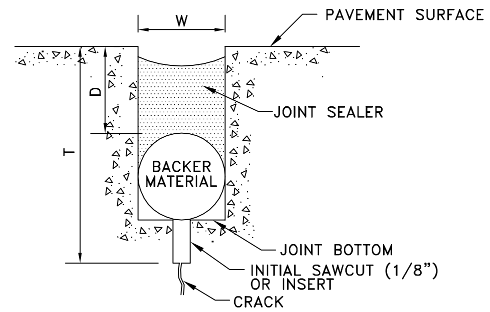

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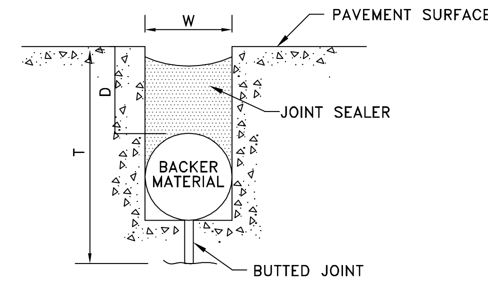
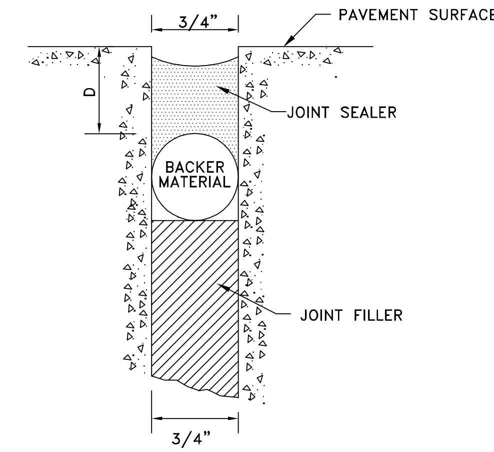


EXPANSION JOINT



JOINT SEALANT DETAILS

(BACKER MATERIAL)

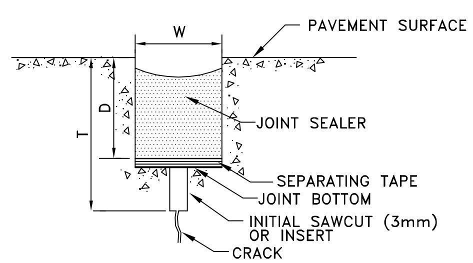
N.T.S.

W = WIDTH OF SEALANT RESERVOIR (1/2" (MIN), 5/8" (MAX))
D = DEPTH OF SEALANT (1.0 TO 1.5W)
T = DEPTH OF INITIAL SAWCUT OR INSERT TYPE JOINT FORMER (CONTRACTION JOINT) SHALL BE 1/4 SLAB THICKNESS

NOTE 1: BACKER MATERIAL SHALL MEET THE REQUIREMENTS OF ACI 504R PARAGRAPHS 2.8, 3.4.6.2, 3.4.6.3 AND TABLE AS APPLICABLE.

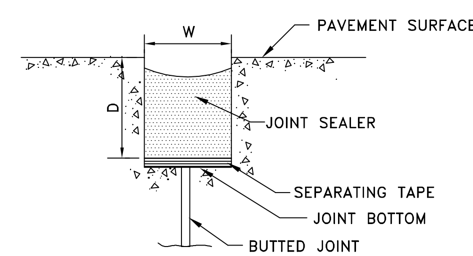
NOTE 2: TOP OF SEALANT WILL BE 1/8" TO 1/4" BELOW TOP OF PAVEMENT SURFACE FOR EXTERIOR PAVEMENTS & TRIMMED TO BE LEVEL W/INTERIOR PAVEMENTS.

CONTRACTION JOINT



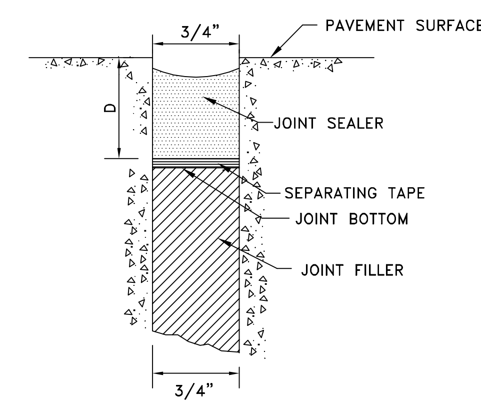
JOINT SEALANT DETAILS
(SEPARATING TAPE)

CONSTRUCTION JOINT



JOINT SEALANT DETAILS
(SEPARATING TAPE)

EXPANSION JOINT



JOINT SEALANT DETAILS

(SEPARATION TAPE)

N.T.S.

W = WIDTH OF SEALANT RESERVOIR (1/2" (MIN), 5/8" (MAX))
D = DEPTH OF SEALANT (1.0 TO 1.5W)
T = DEPTH OF INITIAL SAWCUT OR INSERT TYPE JOINT FORMER (CONTRACTION JOINT) SHALL BE 1/4 SLAB THICKNESS

NOTE 1: SEPARATING TAPE SHALL MEET THE REQUIREMENTS OF ACI 504R PARAGRAPHS 2.8, 3.4.6.2, 3.4.6.3 AND TABLE AS APPLICABLE.

NOTE 2: TOP OF SEALANT WILL BE 1/8" TO 1/4" BELOW TOP OF PAVEMENT SURFACE FOR EXTERIOR PAVEMENTS & TRIMMED TO BE LEVEL W/INTERIOR PAVEMENTS.

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AMMUNITION/EXPLOSIVES TEST BUILDING
JOINT SEALANT DETAILS

Sheet Number:

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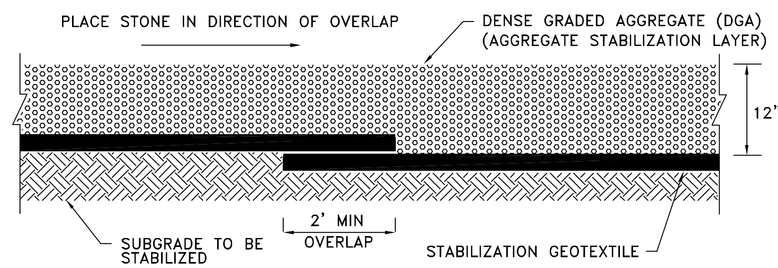

SUBGRADE STABILIZATION SECTION DETAIL

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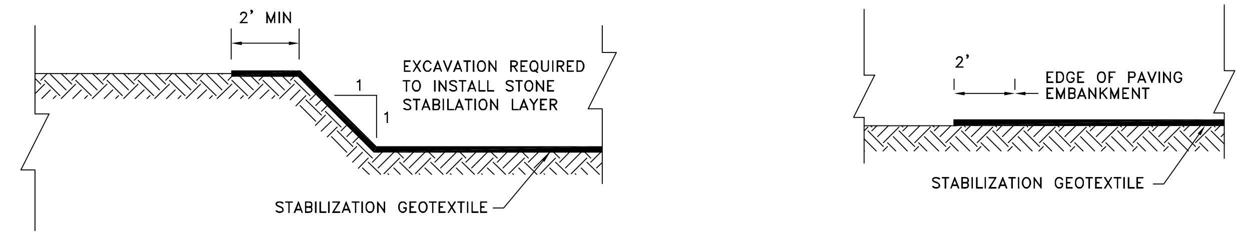
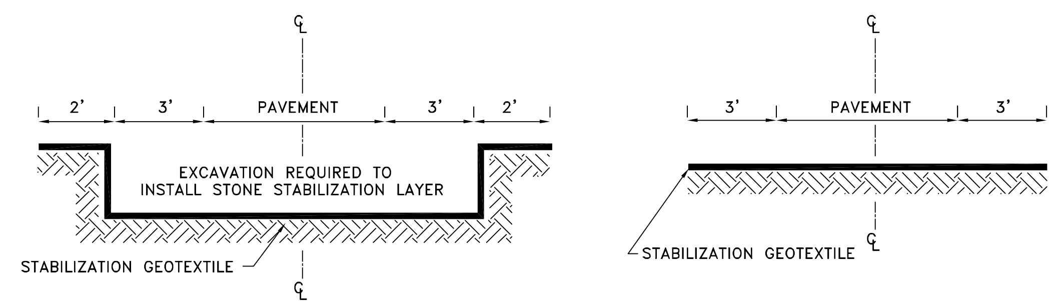


(CUT AREA) (FILL AREA)

LONGITUDINAL TERMINATION

N.T.S.



(CUT AREA) (FILL AREA)

CROSS-SECTION SUBGRADE STABILIZATION

N.T.S.

SUBGRADE STABILIZATION NOTES:

1. LOCATION: SUBGRADE STABILIZATION IS REQUIRED AS INDICATED IN SPECIFICATION SECTION 02300 & 02722 AND AS DIRECTED BY THE CONTRACTING OFFICER.

2. LIMITS OF PLACEMENT: THE AGGREGATE STABILIZATION LAYER SHALL EXTEND A MINIMUM OF 3 FEET BEYOND ALL EDGES OF THE DESIGNATED PAVED AREAS TO BE STABILIZED.

3. SURFACE PREPARATION: THE CONTRACTOR SHALL REMOVE ANY SURFACE MUD AND PLACE THE STABILIZATION GEOTEXTILE DIRECTLY ON THE UNDISTURBED SUBGRADE.

4. STABILIZATION GEOTEXTILE REQUIREMENTS:

A. GENERAL: REFER TO SPECIFICATION SECTION: 02722 FOR STABILIZATION GEOTEXTILE REQUIREMENTS.

B. GEOTEXTILE OVERLAP: IF MORE THAN ONE ROLL WIDTH OR LENGTH OF GEOTEXTILE IS REQUIRED, OVERLAP THE TWO WIDTHS A MINIMUM OF 2 FEET.

5. PLACEMENT OF AGGREGATE STABILIZATION LAYER:

A. DO NOT DRIVE DIRECTLY ON THE GEOTEXTILE.

B. BACK DUMP THE DGA BASE COURSE MATERIAL ONTO THE GEOTEXTILE.

C. SPREAD OUT THE DGA IN THE DIRECTION OF ANY OVERLAP OF THE GEOTEXTILE WHILE MAINTAINING A MINIMUM OF 12 INCHES OF DGA COVER OVER THE GEOTEXTILE AT ALL TIMES.

6. EQUIPMENT FOR SURFACE PREPARATION AND AGGREGATE PLACEMENT: ALL OF THE ABOVE WORK SHALL BE DONE WITH TRACKED VEHICLES. PNEUMATIC-TIRED VEHICLES SHALL BE LIMITED TO MINIMUM HAULING EQUIPMENT NECESSARY TO COMPLETELY PLACE THE AGGREGATE STABILIZATION LAYER.

7. ANTICIPATED RUTTING AND REMEDIAL WORKING OF AGGREGATE STABILIZATION LAYER: THE CONTRACTOR CAN ANTICIPATE INITIAL RUTS OF UP TO 6 INCHES IN DEPTH TO DEVELOP DURING SUBSEQUENT OPERATION OF PNEUMATIC-TIRED VEHICLES ON THE AGGREGATE STABILIZATION LAYER. DO NOT GRADE OUT THE RUTS. BACK DUMP ADDITIONAL DGA BASE COURSE MATERIAL AND CONTINUE TO FILL IN THE RUTS BACK TO REQUIRED STABILIZATION GRADES UNTIL A STABLE SURFACE IS ACHIEVED.

8. THE CONTRACTOR SHALL OPERATE ON THE AGGREGATE STABILIZATION LAYER AT ALL TIMES AND SHALL MINIMIZE CONTAMINATION OF THE SURFACE WITH MUD, SOIL, OR OTHER CONSTRUCTION MATERIALS OR DEBRIS.

9. REFERENCE SPECIFICATION SECTION 02722 FOR SUBGRADE STABILIZATION REQUIREMENTS.

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PLATE | DRAWING NUMBER X-XXX-XX-XX | FILE NAME det-3
SCALE: AS SHOWN | DATE: MAY 2004 | PLT SCALE: 1:1

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SUBDRAIN DETAILS & SUBGRADE STABILIZATION DETAILS & NOTES

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APPENDIX E

Foundation Calculations
Slab Loading Charts

Computed By: DLF | Checked By: CEF | 29 April 04

Depth (feet)	* $\bar{P}$ (tsf)	C_N	DH-1 N_{field}	DH-1 N_{cor}	DH-1 N_{avg}	DH-2 N_{field}	DH-2 N_{cor}	DH-2 N_{avg}	DH-3 N_{field}	DH-3 N_{cor}	DH-3 N_{avg}
0-1.5	0.05	1.9	9	17	17	6	11	11	4	8	8
2.5-4	0.16	1.8	7	13	15	9	16	14	15	27	18
5-6.5	0.21	1.8	7	13	14	7	13	13	10	18	18
7.5-9	0.30	1.4	15	21	16	11	15	14	11	15	17
10-11.5	0.37	1.3	5	7	14	12	16	14	12	16	17
12.5-14	0.45	1.3	10	13	14	9	12	14	8	10	16
15-16.5	0.52	1.2	17	20	15	12	14	14	13	16	16
17.5-19	0.59	1.2	11	13	15	13	16	14	9	11	15
20-21.5	0.66	1.1	11	12	14	16	18	15	21	23	16
22.5-24	0.74	1.1	10	11	14	12	13	14	14	15	16
25-26.5	0.81	1.1	13	14	14	25	28	16	22	24	17
27.5-29	0.88	1.1				11	12	15	9	10	16
30-31.5	0.95	1.0				11	11	15	13	13	16

* use gw @ 2' $\gamma_m = 120$ pcf . $\gamma' = 58$ pcf

$C_N = 2 - (1.14\,\bar{p})$ $\bar{p} < 0.25$ TSF

$C_N = 0.77 \log_{10} \dfrac{20}{\bar{p}}$ $\bar{p} \geq 0.25$ TSF

N_{avg} = Cumulative Average Depth

∴ Conservatively use $N_{DESIGN} = 14$

Foundation Design

Per Structural Engineer, $\Sigma V\downarrow = 25$ kips

$\Sigma V\uparrow = 42$ kips - Resisted by Dead load

$\Sigma H = 23$ kips - Resisted By Slab

$D_{f_{MIN}} = 29"$ (2.4')

A Exterior footings

Exterior footing is grade Beam. Per Str. Eng, based upon Distribution of Load @ Column Base Plates, MIN Bearing Area = 2' wide × 8' length = 16 ft²

∴ a. Model As Column: $q_c = \frac{25^k}{2' \times 8'} = \underline{\underline{1563}}$ psf

b. Model As Wall: $q_c = \frac{25^k}{8'} = 3.1$ kips/Lf

B Interior Wall footings

Per Str. Dwngs, $B = 3'$ & Brg elev = 17.5'

∴ for ff = 21', $D_f = 21 - 17.5 = \underline{3.5'}$

$Q_{max} = 2.4$ kips/Lf

$B = 3'$ ∴ $q_c = \frac{2.4\ k/Lf}{3'} = \underline{\underline{800}}$ psf

Computed By: DLF | Checked By: CG | 29 April 04

MATS: Use twice value on horizontal lines (p. 326)

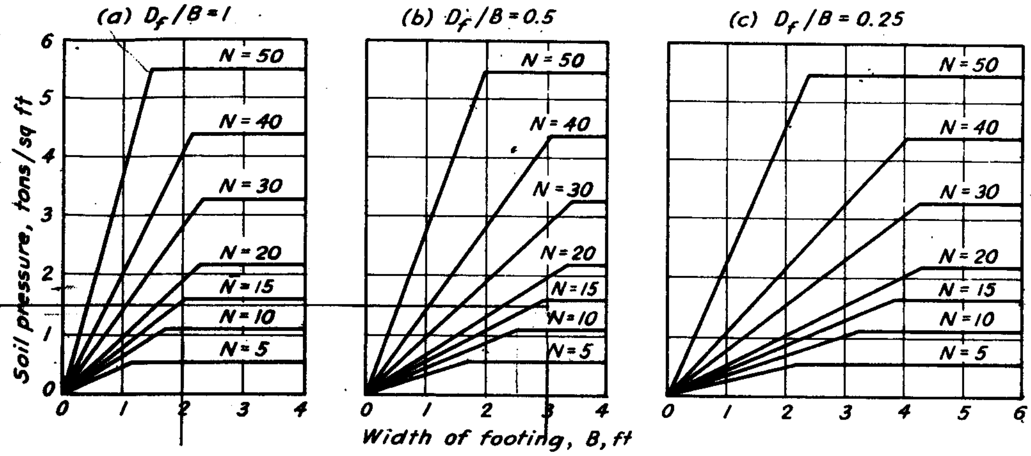


FIGURE 19.3. Design chart for proportioning shallow footings on sand.

$D_{f_{min}} = 2.4'$ - conservative $\qquad N_{Design} = 14$

$B_{max} = 3'$ (interior) & $2'$ (exterior)

$\therefore \dfrac{D_f}{B} = \dfrac{2.4}{3'} = 0.8 \quad \& \quad \dfrac{2.4}{2} = 1.2$

$\therefore$ from fig 19.3 $q_{all} = 1.5$ tsf

$D_w = 2' \quad \therefore C_w = 0.5 + \left(0.5 \dfrac{D_w}{D_f + B}\right) = 0.68$ (with $D_w = 2'$, $D_f = 2.4'$, $B = 2'$)

$\therefore q_{all} = q_{all}(\text{fig } 19.3) \cdot C_w$

* $\therefore q_{all} = 1.5 \text{ tsf} \cdot 0.68 = \underline{1.02} \text{ tsf}$ (2000 psf)

* Based upon conservative $D_w = 2.0'$, $D_{f_{min}}$ & $B = 2.0'$

$\therefore q_a > q_c$ (2000 psf > 1563 psf) $\therefore$ OK

3-3. Stationary live loads.

Floor slabs on grade should have adequate structural live loads. Since floor slabs are designed for moving live loads, the design should be checked for stationary live loading conditions. Table 3-1 lists values for maximum stationary live loads on floor slabs. For very heavy stationary live loads, the floor slab thicknesses listed in table 3-1 will control the design. Table 3-1 was prepared using the equation

$$w = 257.876s \sqrt{\frac{kh}{E}} \qquad \text{(eq 3-1)}$$

where

- w = the maximum allowable distributed stationary live load, pounds per square foot
- s = the allowable extreme fiber stress in tension excluding shrinkage stress and is assumed to be equal to one-half the normal 28-day concrete flexural strength, pounds per square inch
- k = the modulus of subgrade reaction, pounds per cubic inch
- h = the slab thickness, inches
- E = the modulus of elasticity for the slab (assumed to equal 4.0 x 106 pounds per square inch)

The above equation may be used to find allowable loads for combinations of values of s, h, and k not given in table 3-1. Further safety may be obtained by reducing allowable extreme fiber stress to a smaller percentage of the concrete flexural strength have been presented by Grieb and Werner, Waddell, and Hammitt (see Biblio). The selection of the modulus of subgrade reaction for use in table 3-1 is discussed in paragraph 4-2*d*. The design should be examined for the possibility of differential settlements which could result from nonuniform subgrade support. Also, consideration of the effects of long-term overall settlement for stationary live loads may be necessary for compressible soils (see TM 5-818-1/AFM 88-3, Chap. 7).

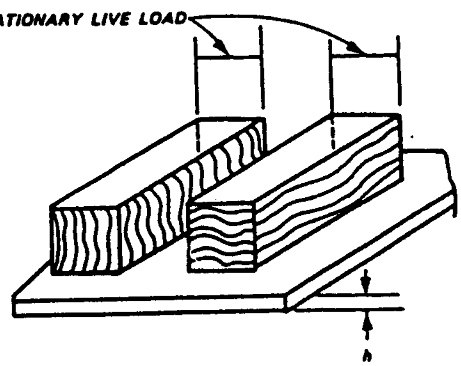
Table 3-1. Maximum allowable stationary live load

Slab Thickness (inches) h	Stationary Live Load w in lb/ft² for These Flexural Strengths of Concrete: 550 lb/in²	600 lb/in² 635	650 lb/in²	700 lb/in²
6	868	947 1002	1,026	1,105
7	938	1,023	1,109	1,194
8	1,003	1,094	1,185	1,276
9	1,064	1,160	1,257	1,354
10	1,121	1,223	1,325	1,427
11	1,176	1,283	1,390	1,497
12	1,228	1,340	1,452	1,563
14	1,326	1,447	1,568	1,689
16	1,418	1,547	1,676	1,805
18	1,504	1,641	1,778	1,915
20	1,586	1,730	1,874	2,018

∴ h = 6.5"

$\frac{7-6}{1109-1026} = \frac{7-6.5}{1109-x}$

∴ x = 1068



NOTE: Stationary live loads tabulated above are based on a modulus of subgrade reaction (k) of 100 lb/in³. Maximum allowable stationary live loads for other moduli of subgrade reaction will be computed by multiplying the above-tabulated loads by a constant factor. Constants for other subgrade moduli are tabulated below.

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Modulus of Subgrade reaction	25	50	100	125	200 (210)	300	350
Constant factor	0.5	0.7	1.0	1.1	1.4 (1.32)	1.7	1.9

For other modulus of subgrade reaction values, the constant values may be found from the expression $\sqrt{k/100}$.

for Kef = 150 pci, constant factor = 1.2

h = 6" for flex strength = 635 psi.

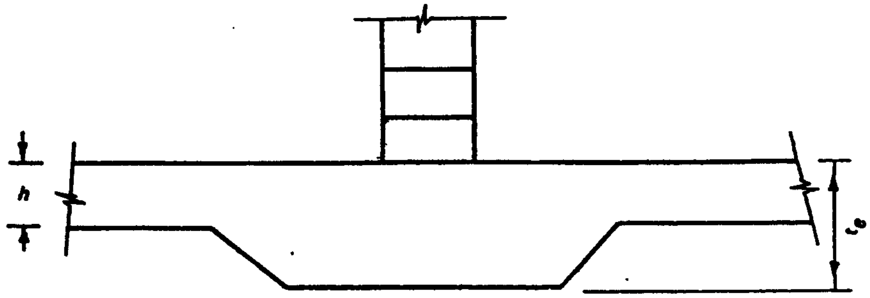
3-4. Wall loads.

Floor slabs on grade should have adequate thickness to carry wall loads. Tables 3-2 and 3-3 show the minimum thicknesses of thickened slabs for various wall loads. The equations used to compute these values are included in appendix B. When slab thickness required for wall loads exceeds that required for moving live loads or stationary live loads, the slab will be thickened in accordance with figure 3-1. The safety factor for the design was considered by using a reduced allowable tensile stress of the concrete, σ_t, which was computed using the equation $\sigma_t = 1.6\sqrt{f'_c}$, where f'_c is the ultimate compressive strength of the concrete. If wall loads exceed the tabulated values shown in table 3-2, separate wall footings are suggested. Figure 3-1*a* shows the widths of thickened slabs when the interior wall loads are near the slab center. A recommended transition is also shown. The thickened slab width is determined by the same theory as the wall loads. The slab under the wall is widened to the point where the stress in the thinner slab section does not exceed the allowable tensile stress of $1.6\sqrt{f'_c}$. Figure 3-1*b* shows a slab loaded near a keyed or doweled edge. Figure 3-1c shows a recommended slab thickening for a slab loaded near a free edge. The width of the thickened edge varies depending upon the width of the wall.

3-5. Unusual loads.

Information regarding floor slab requirements for special purpose ordnance, engineer, or transport vehicles producing loads significantly greater than those defined herein should be requested from Headquarters, Department of the Army (HQDA) (DAEN-ECE-G) Washington, DC 20314-1000 or Headquarters, Air Force Engineering and Services Center (DEMP), Tyndall AFB, Fla. 32403.

Table 3-2. Minimum thickness of thickened floor slab for wall load near center of slab or near keyed or doweled joint



Thickness of Thickened Floor Slab, t_e, (inches)	Slab Line Load Capacity, P, (lb/lin ft)				
	Flexural Strength[a] of Concrete (lb/in^2)				
	550	600	635	650	700
4	425	455		485	510
5	565	600		640	675
6	710	755		805	850
7	860	920		975	1,030
8	1,015	1,080		1,150	1,215
9	1,175	1,255		1,330	1,410
10	1,340	1,430		1,520	1,605

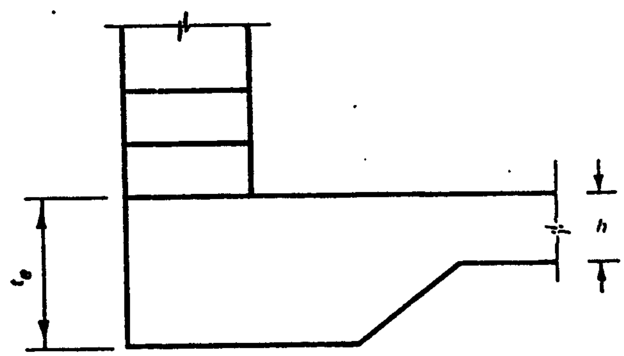
NOTE: The allowable wall loads are based on a modulus of subgrade reaction (k) of 100 pounds per cubic inch. The thickness of the thickened slab will be computed by multiplying the above thicknesses by a constant factor. Constants for other subgrade moduli are tabulated below.

Modulus of Subgrade reaction k	25	50	100	125	200	300
Constant factor	1.3	1.1	1.0	0.95	0.9	0.8

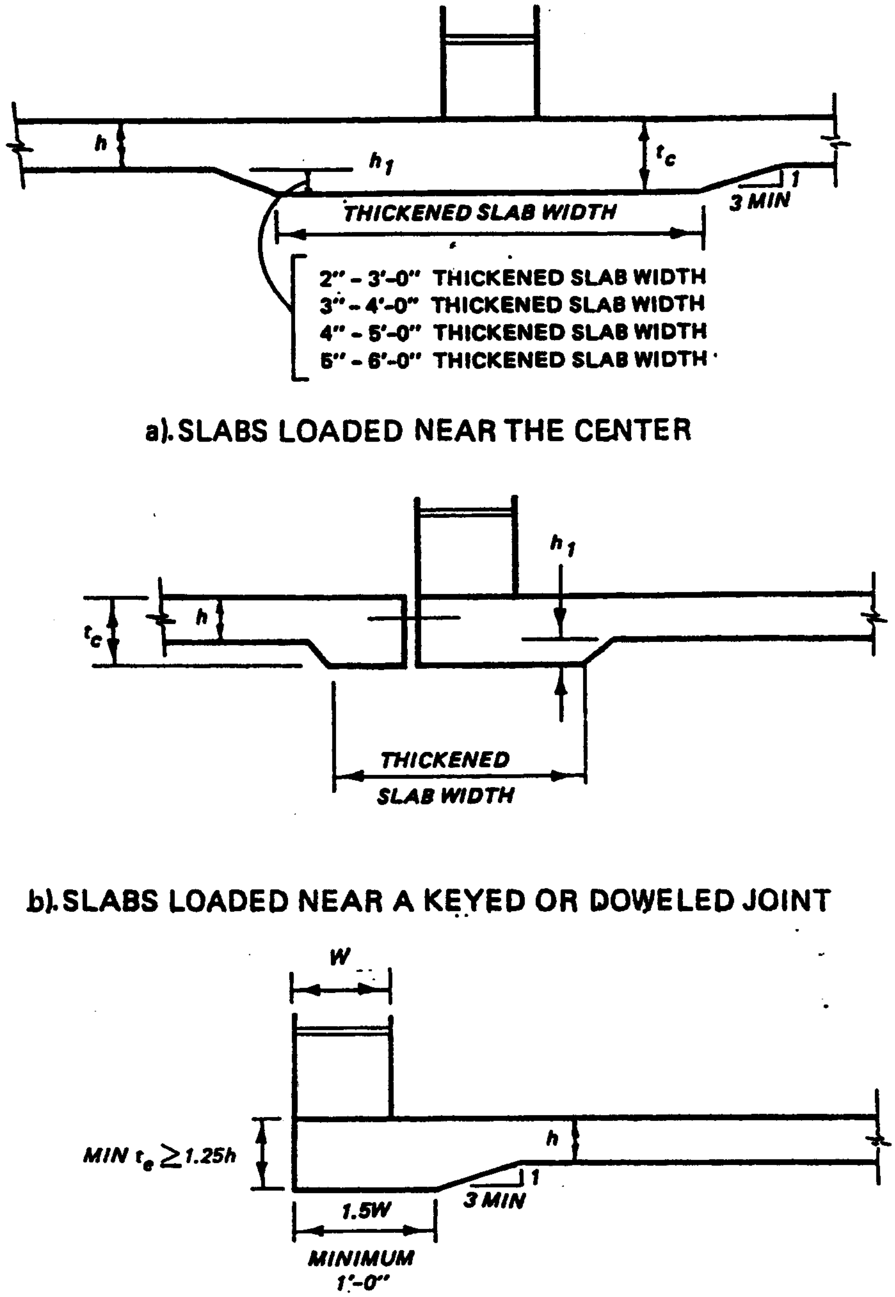
For other modulus of subgrade reaction values the constant values may be found from $\sqrt[5]{100/k}$. K_{eff} = ~~140 pci~~ 150 ∴ f = 0.92

[a] For this application, the flexural strength of concrete was assumed equal to $9\sqrt{f'_c}$ where f'_c is the specified compressive strength of concrete (lb/in^2).

Table 3-3. Maximum allowable wall load near free edge



Thickness of Thickened Slab, t_e (inches)	Slab Line Load Capacity, P (lb/lin ft) Flexural Strength of Concrete, (lb/in^2) 550	600	650	700
4	330	355	375	395
5	435	465	495	525
6	550	585	620	660
7	665	710	755	800
8	785	840	890	945
9	910	975	1,035	1,090
10	1,040	1,110	1,180	1,245



a). SLABS LOADED NEAR THE CENTER

b). SLABS LOADED NEAR A KEYED OR DOWELED JOINT

c). SLABS LOADED NEAR A FREE EDGE

Figure 3-1. Widths of thickened slabs and slab edge conditions under wall loads.